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ECONOMIC ANALYSIS PROCEDURES FOR ADP.(U)

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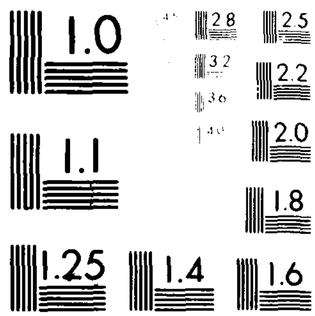

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ECONOMIC ANALYSIS PROCEDURES FOR ADP

MARCH 1980

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WASHINGTON, D.C. 20374

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1. The purpose of this manual is to provide basic guidance for conducting and reviewing economic analyses. The guidance provided herein is consistent with the information promulgated in SECNAVINST 7000.14.B, "Economic Analysis and Program Evaluation for Navy Resource Management" and highlights the elements of economic analysis as it pertains to ADP.

2. Revisions of the manual will be published periodically. Users of the document are encouraged to submit recommended changes and comments to improve the publication to Commander, Naval Data Automation Command, ATTN: ADP Plans and Programs Department, Building 166, Washington Navy Yard, Washington, DC 20374.

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FOREWORD

Virtually every aspect of defense endeavors involves computer support. This support extends to systems for logistics; financial management and administration; health care delivery; command, control, and communications; intelligence; tactical operations; and weapon systems. Because Computer Systems require a major investment of time and resources it is important that management be aware of all available alternatives and the costs and benefits associated with each. Economic Analysis provides the tools needed to evaluate alternatives and reduce them to bases which provide for ease of comparison.

This book establishes a procedural routine for conducting economic analysis. The approach throughout is to assume that the reader is the novice in the field of cost/benefit analysis and to develop material slowly from a few very basic economic and common sense principles. While the techniques described throughout the book can be easily applied to all types of investment problems, the scope of this book is limited to economic problems of choice within the ADP arena.

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Part I

Introduction

CHAPTER 1

THE CONCEPT OF ECONOMIC ANALYSIS

INTRODUCTION

Every manager devotes considerable time and effort to planning for the future, and every plan is concerned primarily with allocating scarce resources. This book explains a process which will aid the manager in making resource allocation decisions. This method of aproaching a complex problem of choice is called Economic Analysis.

Economic Analysis concerns the basic problem of economic choice (value received for value sacrificed) and as such, is applied by each of us implictly and informally whenever we make a decision in the marketplace. For example, when we buy a car we do not take the first one we see. We look around until we find a model that suits our needs and our pocketbooks. In effect, we make an economic analysis, even if we don't call it that.

This book was written in order to establish a procedural routine for personnel who have little or no experience with economic analyses. It will also be of value to those supervisors and functional managers who must initiate or review economic analyses. While the techniques described throughout the book can be easily applied to all types of investment problems, the scope of this book is limited to economic problems of choice within the ADP arena.

ECONOMIC ANALYSIS DEFINED

Economic analysis is a systematic approach to evaluating the relative worth of proposed projects. The technique is based on the premise that there are alternative ways of reaching an objective and each alternative requires certain resources and produces certain results. The economic analysis examines and relates the costs, benefits and uncertainties of each alternative in order to determine the most cost effective means of meeting the objective. In general, economic analysis can be considered as a kind of consumer's research to assist in getting the most for the resources to be expended and not as a search for the cheapest solution regardless of effectiveness.

Three basic principles must be incorporated in the economic analysis:

1. The analysis must investigate all reasonable alternative methods of satisfying a given objective. To be reasonable an alternative must be both technologically and operationally feasible.

2. The analysis must consider both current and future expenditure patterns of all proposals.

3. Since there is a "time value of money," the analysis must consider not only how much a proposal will cost, but also when the expenditures will be made. This consideration is included in the analysis by expressing each alternative's life-cycle costs in terms of its "present value."

USES OF ECONOMIC ANALYSIS

Economic analysis is generally used in two ways: to assess the economic consequences of a decision already made, or as part of the decision-making process in the first place. The distinction lies in the relationship of the analysis to the planning and decision process (as suggested in Figure 1-1).

USES OF ECONOMIC ANALYSIS

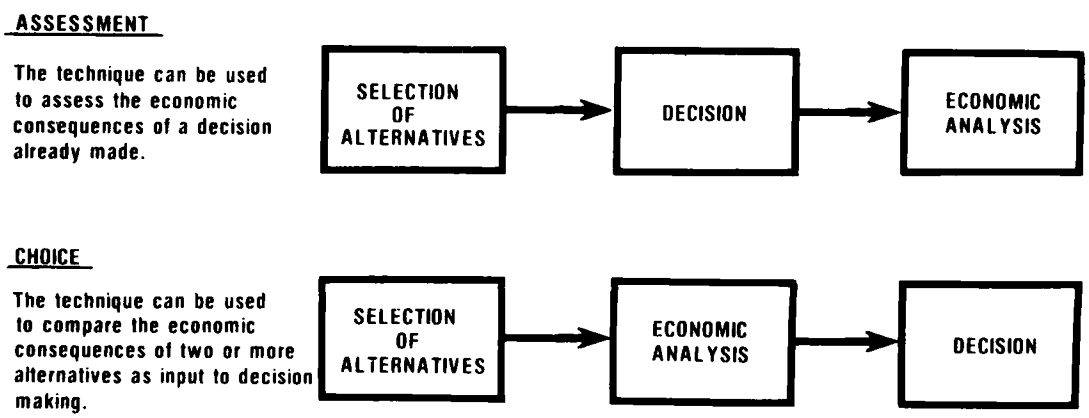


Figure 1-1

The first use -- assessment -- assumes that a given decision, or a set of decisions has already been made and that it is desirable to assess the economic consequences following this action. The results can then be used to determine future courses of action to take. For example, suppose a data processing installation (DPI) is in existence serving a number of customers. In order to recoup his costs, the DPI manager has decided to implement a user charge-back system. By performing an economic analysis he can assess all costs associated with operating the installation. Using this information he could then determine an equitable means of charging his customers.

The second use -- choice -- assumes that a decision will be made based on the economic consequences of two or more alternatives. For example, suppose that the existing space in a computer room is considered inadequate. Several options

for improvement are available: build new, renovate, buy or rent another existing facility. In this case a decision would not be made until all costs and benefits of each alternative are evaluated.

ECONOMIC ANALYSIS AND THE BUDGET

An economic analysis will seldom lead to cost estimates which are consistent with the budget. This inconsistency occurs for several reasons. First, a budget is a spending plan which reflects actual out of pocket expenses to be incurred. An economic analysis considers not only out of pocket costs, but also opportunity costs (for example, resources already on hand which have an alternative use). Second, budgets take into consideration inflation, whereas, economic analyses generally consider costs in terms of constant dollars. Third, fringe benefits must always be included in an economic analysis. And finally, future costs and benefits in an economic analysis are stated in terms of their present values. Discounting is appropriate in an economic analysis because resources (or monies) received (or used) today are worth more than those monies received or used in the future. Discounting permits cost and benefit streams with different time phasing to be compared on an equal basis.

LIMITATIONS

Economic analysis is subject to a number of limitations.

First, economic analysis does not normally establish priorities among various goals and objectives -- it merely seeks to determine the most cost-effective means of satisfying a *given* objective.

Second, an economic analysis is not in itself a decision-making process for choosing the most preferred means of meeting an objective; it is only an *input* to the decision-making process. The decision-maker must weigh the results of the analysis against other factors, such as safety, health, morale, environmental impact, political considerations, and national priorities. In short, economic analysis is not a substitute for sound judgement. Rather, by systematically quantifying what *is* quantifiable, it allows the decision-maker to focus his judgement more sharply on those areas where it is most vitally needed.

Finally, an economic analysis cannot provide results which are more valid than the input data. Judicious formulation of assumptions and careful estimation of costs and benefits are therefore critical to the economic analysis process.

Yet no matter how much care is exercised during these

stages, uncertainty cannot be eliminated completely. Economic analysis necessarily involves assumptions, projections, or estimates of future events whose outcomes cannot be known with certainty until they occur. (There are, however, systematic techniques for assessing the impact of uncertainty on analysis results. These techniques are examined in Chapter 17).

WHEN ECONOMIC ANALYSIS IS NOT NEEDED

A complete economic analysis of even a fairly limited problem can become very involved and expensive. Therefore, an analysis is unnecessary when it can be shown that the benefits to be realized are not commensurate with the effort involved. Other exemptions to the economic analysis requirements occur when DOD Instructions or Directives prescribe alternate replacement criteria or equipment tradeoff standards and when legislative action or prior high level management decision prevails.

CHAPTER 2

THE ECONOMIC ANALYSIS PROCESS

INTRODUCTION

The Economic Analysis Process is a systematic procedure for comparing alternative means of meeting a specific objective. The process consists of six key elements. The elements are depicted diagramtically in Figure 2-1. They are:

1. Establishing and defining the goal or objective.

2. Formulating appropriate assumptions.

3. Searching out alternatives for accomplishing the objective.

4. Determining the costs (inputs) and the benefits (outputs) of each alternative.

5. Comparing costs and benefits of the alternatives.

6. Testing the sensitivity of the analysis outcome to major uncertainties.

The results of the analysis should be documented in a written report. The report should describe each of the key steps and should identify pertinent background information, the scope of the analysis, the methodology employed and the conclusions and recommendations drawn. A suggested format is provided in Appendix A. Each of the key steps is described below.

DEFINING THE OBJECTIVE

The most important step in the economic analysis process is defining the objective. Most simply stated, an objective is some fixed standard of accomplishment. An objective should be stated in terms of a mission or goal. The actual wording of the objective is critical in that it should reflect a totally unbiased point of view concerning the method of solving the problem. For example, if the goal is to provide a secure, climate controlled, working space for electronic equipment with access to utilities, users and data, state your objective as such. Do not say that the objective is to construct an ADP center, which might rule out modification of existing facilities or rental of space. Examples of economic analysis objectives include:

ECONOMIC ANALYSIS
THE PROCESS

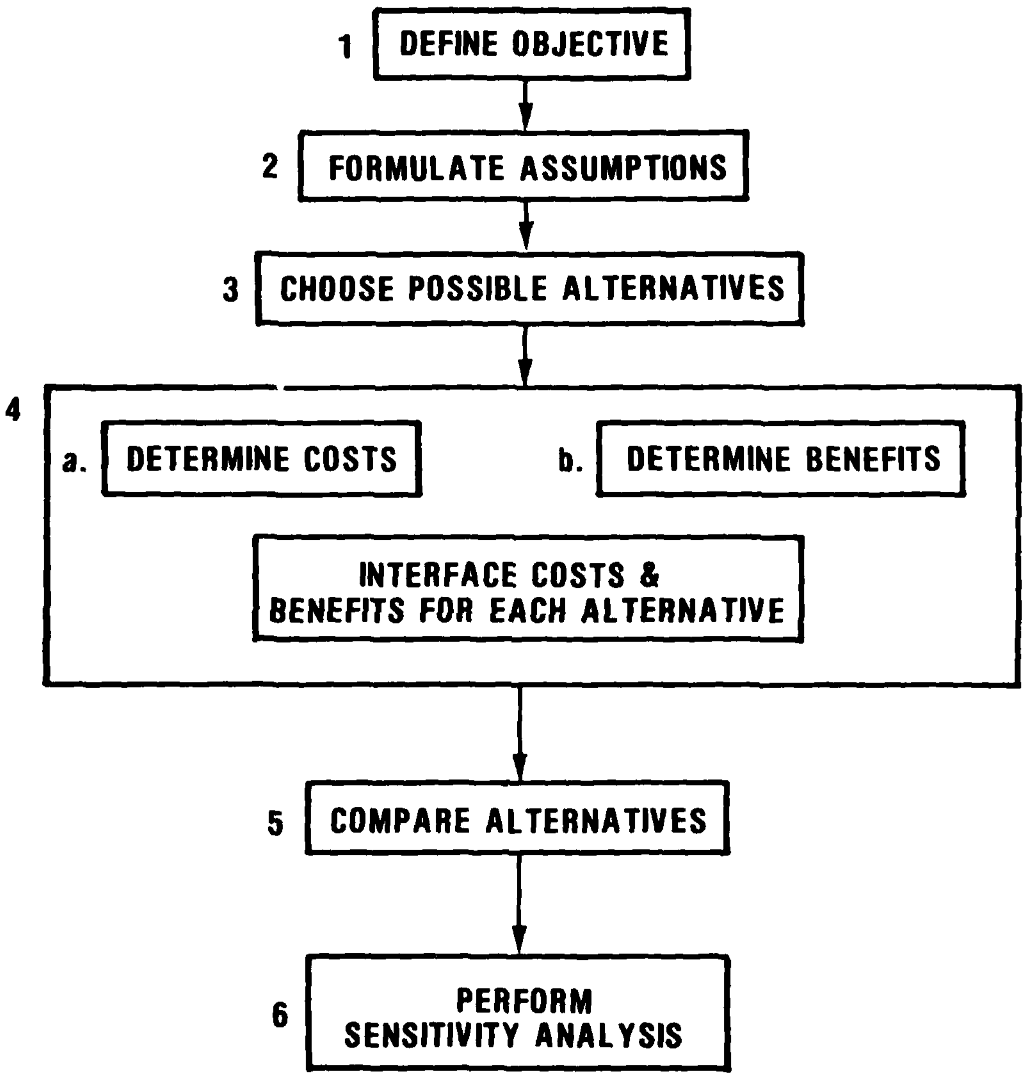


Figure 2-1

- To process the IDA workload in the Northeast region.

- To improve ADP service at the Naval Air Engineering Center while reducing the cost of ADP.

- To free the CINCPACFLT WWMCCS H6060 computer of all non-command and control applications and provide the 25% surge capacity required for crisis and exercise operations.

- To examine the cost effectiveness of installing a B-3500 at NAVDAF Newport.

- To evaluate the economic feasibility of establishing a NARDAC at Newport, Rhode Island.

ASSUMPTIONS

In all phases of government activity managers operate in an environment of restrictions limiting what they can and cannot do. For purposes of analyses these restrictions are presented as assumptions and constraints.

Assumptions are explicit statements used to describe the present and future environment upon which the economic analysis is based. Every analyses, no matter how formal or informal, will be filled with assumptions. We simply do not know enough with certainty about the real world to avoid making assumptions, particularly when we are dealing with the future. The purpose of the assumption is not to limit the analysis, but to reduce complex situations to problems of manageable proportions. All assumptions must be carefully chosen and identified as such so that the decision-maker realizes the basis under which the alternatives were subsequently developed and evaluated.

Four rules to observe in making assumptions are:

1. Don't confuse assumptions with facts. Make assumptions only when they are absolutely necessary to bridge gaps in essential information that cannot be obtained -- even after diligent research.

2. Be certain the assumptions are realistic and not mere platitudes or wishful thinking.

3. State assumptions positively, using the word "will." For example, "The ADP system will have an economic life of eight years." "MILCON funds will be available in FY 8X."

4. Ask yourself if your conclusions would be valid if one of the assumptions did not hold. If the answer is yes,

then eliminate the assumption, because it is not a requirement that must be met.

Examples of assumptions include the estimated future workload, the estimated useful life of an asset, and the period of time over which alternatives will be compared.

Constraints are factors external to the relevant environment which limit alternatives to problem solutions. They may be physical, as with a fixed amount of space; time-related, as with a fixed deadline; financial, as with a fixed or limited amount of resources; or institutional, as with organizational or defense policy/regulations. Whatever their particular characteristics, these external constraints or barriers are beyond the control of the manager -- and provide boundary limitations for alternative solutions to a particular problem.

Caution must be exercised in determining assumptions and constraints. An alternative is feasible only when it satisfies all the restrictions assumed by the analyst. Use of unduly restrictive assumptions and constraints will bias an analysis, precluding investigation of feasible alternatives. Conversely, failure to consider pertinent assumptions and constraints can cause the recommendation of a technically or institutionally infeasible alternative.

ALTERNATIVES

The next step in the process is to identify all feasible means of meeting the objective. A comprehensive discussion of the techniques and operational characteristics of each alternative must be presented. As a minimum, this discussion should include a description of the method of operation, the volume of workload, the type of equipment used and any other factors unique to the system. In developing alternatives, the analyst must insure that each consider the same mission. All alternatives must satisfy the minimum requirements of acceptability. Later evaluation will reflect the differences in acceptability or effectiveness.

Rarely is it true that there is just one way to attain a given objective (e.g., buy vs. lease, manual vs. automated, repair vs. replace). Thus, the discussion of alternatives must demonstrate that all reasonable options have been explored.

The search for alternative solutions to an existing problem should not overlook the current system. The current system represents the alternative which seeks to identify the level of costs and benefits which would accrue without changing the present method of operation. If a current system exists and is considered feasible, it will serve as a baseline with which to compare new alternatives. Note, that if there is no

feasible current system, there is no baseline.

Other alternatives which should be considered when evaluating an ADP proposal are:

- o Modifying the current system by reconfiguring existing ADP resources, hiring additional personnel, etc.
- o Acquiring the capability from a NARDAC or from another government agency through resource sharing.
- o Contracting with a nongovernmental source to provide the required capability.

Each method of problem solution has its own mix of resources. One method may require a multitude of personnel while another may require a large capital investment. The number of alternatives is usually limited only by the creativity and thoroughness of the problem solver.

Often the analyst preparing an economic analysis is directed to select alternatives which keep within certain constraints; for example, manpower, facilities or funding limitations. Care must be taken to avoid the imposition of arbitrary constraints which in turn unduly limit the number of alternatives available. Such limitation of alternatives would of course simplify the analysis, but they do so at the expense of possibly excluding alternatives that might be better than the ones remaining. Keep in mind that the list of alternatives compiled in the beginning of the study should not be regarded as final. As the analysis proceeds, new and better alternatives might be devised, while those not feasible within the constraints may be eliminated.

ESTIMATING COSTS AND BENEFITS

In actual practice, the step that is usually the most difficult and time-consuming is that of estimating the costs and benefits of each alternative. Most simply stated, costs are inputs, whereas benefits are outputs.

Costs and benefits should be determined for the entire useful life of the project. Appropriate estimates must be made by the year in which the cost is to be incurred or the benefit is to be received. It is only the differences in costs between alternatives that are important to the decision-maker. Costs which would not change under any alternative may be omitted from the analysis, although it is generally a good idea to note this exclusion under the list of assumptions.

Benefits are usually not so easily identifiable as costs but still should be quantified to the maximum extent possible. Those nontangible benefits which are more difficult to evaluate

and quantify, such as "increased morale" or "increased safety" so far as possible should be identified and included in the analysis with a narrative description.

It is important that the analyst research all possible avenues to assure that he has obtained the best available cost and benefit estimates. Because the acceptance of the analysis is dependent upon the credibility of the estimates, it is essential that all sources and derivations of cost and benefit data be documented.

COMPARING ALTERNATIVES

Once costs and benefits for all alternatives have been determined, an evaluation of one proposal against another can be made.

Comparison and ranking can usually be accomplished by one of three general criteria: least cost for a given level of effectiveness, most effectiveness for a given constraint and the largest ratio of effectiveness to cost. These criteria conform to the three basic types of cost/benefit relationships: unequal cost/equal effectiveness, equal cost/unequal effectiveness, and unequal cost/unequal effectiveness.

There could be situations resulting in alternatives having both benefits and costs of equal nature. Preference in these cases would, of course, be determined by noneconomic factors.

The comparison of alternatives are summarized in Table 2-1.

TABLE 2-1

COMPARISON OF ALTERNATIVES

Costs	Benefits	Basis for Recommendation
Equal	Unequal	Most benefits
Unequal	Equal	Least costs
Unequal	Unequal	Highest benefit to cost ratio
Equal	Equal	Other factors

Note that the first two bases for recommendation are really special cases of the third. That is, if all alternatives have the same costs but unequal benefits, then the alternative with the highest benefit measure necessarily has the largest benefit-to-cost ratio; and if all alternatives offer comparable benefits but have unequal costs, then the least-cost alternative has the largest benefit-to-cost ratio.

Techniques which can be used to evaluate and compare alternatives include:

1. Present Value Analysis. A means of bringing all future costs and benefits back to their present worths. This technique is employed in economic analyses whenever the economic life is greater than three years.

2. Uniform Annual Cost. A cost-oriented approach for evaluating alternatives with unequal economic lives.

3. Savings/Investment Ratio. The relationship between future cost savings (or avoidances) and the investment cost necessary to effect those savings. Because savings is a necessary ingredient, this technique can be employed only when there is a *status quo* alternative.

4. Discounted Payback. Technique for determining the period over which accumulated present value savings are sufficient to offset the total present value costs of a proposed alternative. Again, a *status quo* must be involved in order to apply this technique.

5. Break-even Analysis. A procedure which focuses on finding the value of the variable (the break-even point) at which a manager is indifferent regarding two possible courses of action.

6. Benefit/Cost Ratio. A means of showing the relationship between output and cost. This technique is used to assess alternatives having unequal costs and unequal benefits.

SENSITIVITY ANALYSIS

Elements of uncertainty involved in an economic analysis must be carefully examined to determine their effects and influence on the ultimate analysis recommendations. The analyst does this by evaluating those factors having key relationships with the results of the analysis and by exploring the extent and magnitude of the impact. This evaluation is often referred to as sensitivity analysis.

In performing a sensitivity evaluation, an investigation is conducted to determine how the economic analysis results may change with respect to changes in the system parameters or basic assumptions. If a change in a parameter or an assumption results in a proportionately greater change in results, then the study results are said to be *sensitive* to that parameter or assumption.

By including the results of the sensitivity analysis in the final economic analysis presentation, the analyst assures the decision-maker that the uncertainties have been considered.

Part II

Cost/Benefit Identification

CHAPTER 3

GENERAL COST CATEGORIES

INTRODUCTION

An economic analysis must identify and evaluate all anticipated expenditures associated with each proposed alternative over its entire life cycle. Any cost that will be incurred no matter what choice is made, any cost that must be borne regardless of the decision at hand, is not a cost of that particular choice or decision and need not be included in the analysis. For example, if we are evaluating alternate ways of replacing a piece of ADP hardware at a large data processing center we do not need to include the cost of leasing the building which houses the equipment. This cost will remain the same no matter which alternative is selected. Costs which have already been incurred at the time the analysis is made are "sunk costs" and should not be included in the comparison of alternatives. For purposes of the economic analysis, costs are separated into two categories: non-recurring and recurring. Non-recurring costs occur on a one-time basis; they are typically associated with the start-up or implementation of an alternative (though exceptional costs may also be incurred during the operating life-cycle). Recurring costs occur on a repetitive, year-to-year basis; they are needed to sustain an alternative throughout its life-cycle, once it has been implemented. For automated data systems, non-recurring costs basically cover system development and implementation, while recurring costs are incurred to provide routine support and system maintenance.

Implicit in the discussion of costs is an alternative use concept. The alternative value is often referred to as the "opportunity cost" of employing the resources and can be described as those benefits given up because some alternative venture is foregone by using limited facilities for a particular purpose. Opportunity costs are most commonly incurred when resources already on hand are diverted from their current use to be used with a new project (for example, when onboard personnel are tasked with developing and operating a new management information system).

LIFE-CYCLE COSTS

Life-cycle costing results from the principle that the funds necessary to initially undertake a program are not the primary consideration, nor are the funds required in any particular time period; but a decision to undertake a particular course of action should take into account its total cost impact over time. The cost of developing the system must be accounted for as well as the cost of procuring the system, and the cost of operating it. Each of these phases are depicted in Figure 3-1 and defined as follows:

1. Research and Development. Costs primarily associated with the development of new a system or capability to the point where it is ready for introduction into operational use. A system's research and development costs are one-time costs and are, in effect, a function of the nature of the system. Research and development costs are essentialy insensitive to the number of units of the system that will be procured or the length of time that the system will be in operational use. Examples include prototype equipment and test equipment used in a development program.

2. Investment. Costs beyond the development phase to introduce new systems or a new capability into use. Investment costs are a function of the number of units planned for the system. The greater the number of units to be introduced into the program, the higher the investment cost. Such costs are essentially one-time costs per unit.

3. Operations. Recurring costs of operating, supporting, and maintaining the system or capability. Operating costs depend on both the number of units in the program and the length of time that such units are operated, supported, and maintained.

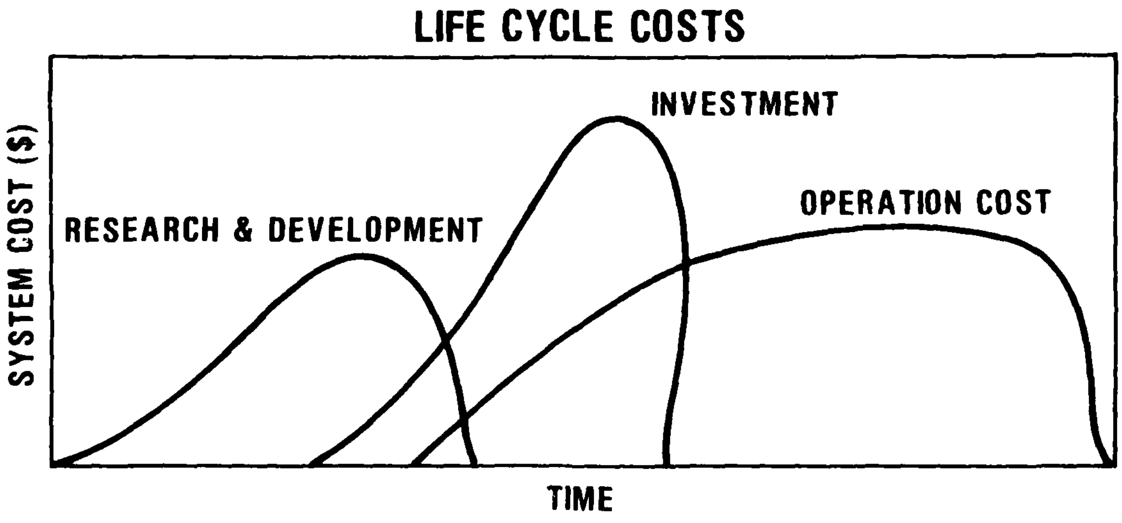


Figure 3-1

DETERMINING THE COST OF RESOURCES

In order to determine the cost of a particular resource, you must first determine if the resource is already available within your organization or if the resource will have to be purchased or acquired. If the resource is not available in house then the cost of the resource is simply the purchase or acquisition price. For example, rental of new hardware or

salaries for new personnel to design or operate the system will be obvious add-ons to the organizational budget and should be included at their acquisition cost.

The more difficult part of cost analysis is determining the value or cost to be placed on resources which are already in house. The first step in estimating these costs is to determine if the resource is being used (or has an alternative planned use) or if it is surplus. If it is not currently being used, then it can be employed in this alternative without denying its use for some other in-house purpose. If the unused resource could be disposed of, the cost is equal to its market or salvage value. Note that the salvage or market value of any unused resource should be used only if the resource would have been sold or reutilized by another activity. If the resource cannot be disposed of or reutilized the cost of using the resource is zero.

The other contingency is that a required resource is available in house but is already being used. Therefore, to employ it in a new use would mean removing the resource from its present use. The cost of using an in-house, but already employed, resource is the cost of replacing or providing the service in which that resource was previously employed (i.e., its opportunity cost). For example, systems analysts who are already on the staff may be assigned to an automated data system design effort; the system might be designed so that it can be accommodated by existing excess mainframe capacity; or, new hardware may have to be acquired and installed in facility space for which some other use had orignially been planned. All these actions have an economic cost since, once each action is taken, the opportunity to use these resources for some other purpose is foregone. For all resources, except facilities, current market value can be based upon the replacement cost of the resource; that is, the price you must pay if you bought the exact same resource (same age, condition, etc.) in the market place.

With facilities, however, the problem of determining the cost is different. If a facility is already completely occupied and some of the area is needed for the alternative being considered, then it will be necessary to have the current occupant displaced. The cost of providing an adequate facility for the displaced occupant is the cost to this alternative. The decision of whom to displace should be based on (1) the space needed for the alternative and (2) the cost of shelter for the displaced occupant.

The identification and costing of resources which are used jointly are two of the most difficult and ambiguous tasks required in an economic analysis. Unless otherwise directed or required, the cost of a jointly used resource should be determined on the basis of how much (incremental cost) costs

will increase if the jointly used resource is employed in the alternative under consideration. For alternatives which result in the elimination of joint functions, the cost savings to be claimed as a credit should be determined on the basis of how much costs will decrease if a resource is used less intensely.

SUNK COSTS

Sunk costs are those costs which have already been incurred or which have irrevocably been committed to a project. They are considered irrelevant in an economic analysis.

The principle of full life-cycle costing applies to all those costs to be incurred after the point of decision, which is to say, only to those cash flows which the decision can affect. What has happened up to date cannot be changed by any choice among alternatives for the future. For example, if a given alternative is linked to a research effort undertaken and completed two years prior to the decision point (i.e., time at which the economic analysis is prepared) at an expense to the Navy of $100,000, the research cost must be disregarded in costing out the alternative. It is a sunk cost which in no way can be affected by the decision at hand.

Although sunk costs should not be included as part of the cost analysis, a narrative account of such costs is generally made to provide additional background information.

NONRECURRING COSTS

Nonrecurring costs are those costs made on a one-time basis. Normally these include expenditures for investments and include all costs associated with the acquisition of equipment, real property and nonrecurring services. Nonrecurring costs may be either additive or nonadditive. Additive costs are unprogrammed or unbudgeted costs of acquiring new resources.

Nonadditive costs are the expenses diverted from existing resources. One-time costs include:

1. Research and Development (R&D) Costs consist of all costs incurred prior to the initial staffing and equipping of a system/program. R&D costs include those necessary to design the system and its components and to perform development testing. The costs essentially end once an alternative is ready to be introduced into use.

2. Investment Costs are costs associated with the acquisition of equipment and real property; nonrecurring services; nonrecurring operation and maintenance (startup) costs; and other one-time investment costs. Investment costs may be spread over several years, and the anticipated years

of incurrence should be identified. Investment costs include:

a. Land acquisition or easement.

b. New construction.

c. Rehabilitation or modification.

d. Equipment (ADPE, telecommunications, etc.).

e. Software purchases.

f. System development.

1. Development of functional requirements.

2. System design, analysis, programming.

3. Testing and conversion.

g. Relocation costs.

h. One-time personnel costs (recruitment, separation, training, travel, etc.).

3. Working Capital is the amount of liquid funds and current assets on hand or on order. Generally, working capital is some form of inventory of consumables or similar resources held in readiness for use or in stock. Working capital changes can be positive (representing additional funding requirements) or negative (representing a reduction in funding requirements).

4. Value of Existing Assets Employed is the value of assets already on hand which are to be used with the new project. This value is included in the investment cost only when the existing asset is currently in use (or has an alternative planned use) on some other project, or was intended for sale. Such existing assets should be included at their fair market value and the basis for arriving at the estimate should be documented.

5. Terminal/Residual Value. In many instances value can be imputed to assets no longer being used. This value can be either terminal or residual. Terminal value is defined as the expected value of buildings, equipment or other assets at the end of their economic lives and is treated as a reduction in the life-cycle cost of the particular alternative for which the use of the asset is intended. Residual value is the computed value of assets at any point in time. Residual value may or may not coincide with terminal value. Terminal/residual value should be applied to existing assets replaced as well as new assets being acquired.

The terminal value of existing assets is the value of assets or property already on hand, the current need for which is eliminated by a proposed project. If this property is then sold, the proceeds benefit the government. If it is redistributed to some other federal or state agency, that agency is benefitted even though there is no reimbursement or cash flow to the agency which controlled the property initially. The fair market value of these replaced assets should be treated as a reduction in the required investment in the economic analysis if, and only if, there is a documented alternative use for the assets.

The terminal value of a new asset is its estimated value at the end of its economic life. Future terminal value is impacted by such factors as the probability of continued need for the facility (for Government or private use), appreciation, and depreciation (physical and functional). The estimated future value of the asset will be applied at the end of its economic life.

Probably the most important criterion for determining the terminal/residual value is what will be done with the asset. Will it be scrapped? Sold? Reutilized? Or will it continue in operation for another cycle? Each of these situations would probably call for a different value.

a. Scrap Value of an Asset. If an asset is to be scrapped, then the only value is the scrap value less costs of dismantling and selling. Scrap values are often so small and occur so far in the future that they may have no significant impact on the decision. In such cases, terminal value need not be included in the analysis. If, however, the scrap value is expected to be significant, this value should be included in the analysis. Accompanying this value should be explicit assumptions used in deriving the estimate.

b. Sale of an Asset. If property is sold, the proceeds benefit the Government because they are included in Miscellaneous Receipts by the Treasury Department. The value will be the actual sale price of the item less costs of the sale.

c. Reutilization of an Asset. If property is redistributed to some other Federal Agency, that agency is benefitted even though there is no reimbursement of cash flow to the agency which controlled the property initially. In this case the asset's value is determined by its worth in the market less costs attributed to redistribution.

d. Continued use of an Asset. Often the need for a service will extend far into the future. When this occurs, the automatic replacement of assets and repeating cash flows will result in a repetitive cycle of expenditures. A single

project involving multiple assets with different lives can be handled two ways. The first is to let the economic life of the dominant asset prevail with subsiding assets being replaced as necessary. The second method is to use the shortest economic life and impute residual value to the asset with the longer life. Residual value in this case is determined by a pro-rata amount. This is true because the project is of an ongoing nature and there is no actual termination taking place. Note, however, if an asset were actually to be sold before the end of its economic life, straight-line depreciation would not be used.

For example, suppose one alternative for expanding an ongoing mission involves acquisition of both buildings and equipment. The new building costs $20 million and has an economic life of 30 years, while the equipment costs $5 million and has an economic life of 10 years. Since the mission is ongoing and will continue to use the same type of equipment the cost analysis can be handled either by using a 30 year life, replacing equipment every 10 years or by using a 10-year life, showing residual value for the building. Using the second method, the residual value could be computed by pro-rating the value of the building. Thus, the residual value of the building after 10 years is 20/30 of the original cost, or $13.3 million.

RECURRING COSTS

Recurring costs, identified as operation costs, are those costs that are incurred on a periodic basis throughout the project period. Such costs are generally acquired each year and also may be additive or nonadditive; they include both civilian and military personnel services, materials, operating supplies, utilities and equipment maintenance.

1. Personnel Costs. This category includes personnel costs (civilian and military), employee benefits, and other personnel related costs.

a. Civilian Personnel Costs. Civilian personnel costs are based on current annual salaries as defined by the General Schedule and Wage Board pay rates. Where specific skills can be identified with an operation/process, the actual grade and step should be used in computing resources. Where a mixture of skills is identified with an operation/process, the resource estimates may be computed using the fifth step of the designated grade level.

(1) Adjustment for fringe benefits. It is important to note that civil service employees cost the government more than the normal amount of their salaries. This is because they draw fringe benefits. These benefits include the Government's contribution for civilian retirement,

disability, health and life insurance and where applicable, social security programs. This value is customarily expressed as a percentage of annual base pay. Guidance for developing fringe benefits is set forth in OMB Circular A-76. The current prescribed rate is 26.0% and is comprised of the following factors:

(a) Retirement and disability (for employees under Civil Service Retirement).	20.4%
(b) Health & life insurance.	3.7%
(c) Other benefits (including work disability, unemployment programs, bonuses and awards, etc.).	1.9%

Using the 26.0% fringe benefit factor, the total personnel cost for an individual who earns an annual base salary of $14,000 is computed as follows:

$14,000 + 26.0% ($14,000) = $17,640

For civilian employees (normally temporary employees) who are not under the Civil Service Retirement System, the Social Security (FICA) cost factor to be applied to salary or wage cost is the actual employer contributon rate for the employees involved. When estimating FICA cost, care must be exercised to assure that the FICA rate is applied only to wages and salaries subject to the tax. Information regarding FICA tax rates and maximum salaries and wages to which they are applicable should be obtained from the appropriate personnel office.

(2) Adjustment for Leave. When the civilian personnel services are specified in terms of the number of people required the base pay automatically includes compensation for sick, holiday and annual leave. However, when the personnel services are specified in terms of number of man-hours of work required, the base pay must be accelerated by a leave factor. This is necessary since, due to such absence, more than one person is required to perform one man-year (2080 man-hours) of work. The OMB prescribed leave rate is 18%.

Once the work requirement has been adjusted to account for leave, the 26.0% fringe benefit factor is then applied. For example, if 400 man-hours are required to perform a certain function, and the average wage is $8 per hour, the total personnel costs would be computed as follows, First, the 18% leave allowance would be included. The adjusted man-hours would be: 400 + (18% x 400) = 472. This amount is

then multiplied by $8 to give the adjusted base cost: 472 x $8 = $3776. Next, the 26.0% fringe benefit factor would be applied to the adjusted figure. Thus total personnel costs would be $3776 + ($3776 x 26.0%) = $4758.

b. Military Personnel Costs. Military personnel costs are based on the current composite standard military rates. These rates are identified in the NAVCOMPT Manual, para 035750. The composite rates provide for the basic pay, incentive and special pay, and certain expenses and allowances included in the active forces military personnel appropriations.

(1) Adjustment for Fringe Benefits. Adjustments must be made to the composite rate to include retirement and other personnel costs which are not included in the composite rate (e.g., medical and commissary costs). Acceleration factors for retirement and other personnel costs are provided in para 036760 of the NAVCOMPT Manual. The current prescribed rate is 25% for officers and 40% for enlisted personnel and is comprised of the following factors:

(a) Retirement Entitlement Accrual Rate (for both officers and enlisted personnel)	17%
(b) Accrual Rate for Other Personnel Costs	
for officers	8%
for enlisted personnel	23%

(2) Adjustment for Leave. Adjustments for leave for military personnel is applied in the same manner as civilian leave. The acceleration factor prescribed by the NAVCOMPT Manual is 20%.

c. Other Personnel Related Costs. Other personnel related costs which pertain to the performance of the function under consideration and should be included in the analysis, if appropriate, are such items as travel, per diem, periodic training, etc.

2. Operating Costs. This category covers operating costs other than labor. Included are:

a. Equipment rental/maintenance

b. Space rental/maintenance

c. Materials and supplies

d. Utilities

e. Communications

f. Commercial services

3. Overhead Costs. Some costs are classified as overhead because it is impossible to associate them directly with products worked on. Included in this category are: accounting, legal, fire and police protection, custodial services and general administrative expenses. When estimating overhead costs associated with an alternative, care must be taken to itemize only the overhead costs which will change as a result of the investment proposed. For example, an alternative which results in a significant decrease in personnel needed to provide a specific service may have little or no effect on the size of the security force.

PRESENTATION OF COST DATA

The analysis should contain a description of each cost element and how it was derived. For example, if personnel requirements were computed based on specific production rates, those production rates should be identified as well as the numbers and grades of people needed.

Once all costs have been discussed they should be presented in a manner which will allow the decision maker to easily review the data. The costs should be considered on a cash flow basis for each year and should be identified by category; nonrecurring or recurring. A sample format for presenting costs is shown in Figure 3-2.

UNDISCOUNTED COSTS

ALTERNATIVE No.

COST ELEMENT	FY0	FY1	FY2	••••••	FYn	TOTAL COST
1. Nonrecurring Costs						
a. ADPE						
b. Site Construction						
c. System Development						
d. Telecommunications						
e. Travel						
2. Recurring Costs						
a. ADPE Maintenance						
b. Personnel						
c. Space Rental						
d. Supplies						
e. Telecommunications						
TOTAL COSTS						

Figure 3-2

CHAPTER 4

INFLATION

INTRODUCTION

For an economic analysis to be a useful decision-making tool, estimates of future costs and benefits must be as realistic as possible. The forecasting of such costs becomes more complicated when there is a persistent and appreciable rise in the general level of prices over time. This condition is commonly referred to as inflation. The problem caused by inflation is not simply that future acquisitions are likely to cost more than today's estimates; but that there exists an uncertainty as to how much more they will cost. It is this uncertainty which so complicates financial planning and the economic analysis as well. Therefore, some method of determining the rate of inflation must be established.

TREATMENT OF INFLATION IN COMPUTATION

Department of Defense policy regarding the treatment of inflation in economic analyses, as promulgated by DODI 7041.3, and SECNAVINST 7000.14B requires a two-phased approach:

1. The analyses should be performed first in terms of constant dollars; i.e., all estimates of costs and savings during the project life should be made in terms of base year prices.

(a) Cost projections may be changed over the period of analysis to reflect only real changes in costs due to changes in amounts of services (for example, an increase in the amount of repair) and improvements at prices in effect at the beginning of the period of analysis.

(b) Cost projections may also be changed due to economies or diseconomies of scale resulting from an increase or decrease in the quantity of goods and services purchased.

2. If inflation is deemed important to the conclusion of the study, a second computation should be made in terms of current dollars. Costs and monetary benefits stated in current dollars reflect the actual amount which will be paid including any amount due to future price changes.

(a) To avoid overestimating and double counting for the effects of inflation, consideration must be given to such factors as contract provisions which may already include provision for inflation, labor agreements, productivity and quantity changes, and the extent to which material is already on hand or will be furnished under fixed price contracts.

(b) Whenever practicable, estimates will include forecasts of changes in price levels on the basis of specific data applicable to a given acquisition. The source of the inflation factors and the rates used are to be included as part of the analysis.

(c) The estimates of inflation will be identifiable by fiscal year. Particular care should be taken when including inflation in cost estimates for more than four years beyond the budget year because of the uncertainty in making forecasts of future national economic conditions and the fact that imputed values for inflation are subject to considerable change.

The requirement to perform a baseline analysis in constant dollars promotes consistency among comparative economic studies. Since the standard 10% discount factors[1] implicitly escalate constant dollar cost estimates at a normal rate, the baseline comparison should suffice in many cases. Moreover, it will be found frequently that introduction of inflation factors into the analysis will have little or no effect in the final ranking of the alternatives.

However, for those instances when an inflated dollar comparison is nonetheless considered appropriate, only a differential inflation rate (i.e., the expected difference between the average long-term rate for the particular cost or cost element) should be applied in the escalation of the base-year annual cost estimate. It must be remembered that a normal escalation component is automatically introduced when discount factors are applied.

MEASURING INFLATION

To determine current and past rates of inflation, measurements of price changes can be made by means of index numbers. A "price index" is a percentage comparison of the total cost of a selection of commodities and services between two periods of time. Index numbers of the aggregate type may be simple or weighted. A simple aggregate index is calculated by adding the total prices actually paid for a group of commodities for a given period, perhaps a year. This total can then be compared, on a percentage basis, with the total prices for the same items for the base period.

Weighting is accomplished by simply multiplying the prices paid for each unit of a commodity by the number of units sold during the given period. A weighted aggregate index avoids the bias of the simple arithmetic average.

The use of price indexes is limited by the fact that

[1]The standard 10% discount factor is discussed in Chapter 9.

only a limited number of commodities can be considered, so only the "most important" are used as a sample. Other problems encountered in constructing price indexes are: getting an accurate sample of prices; allowing for quality improvements; and deciding which average to use (arithmetic or geometric mean, median).

AVAILABLE PRICE INDEXES

The Consumer Price Index (CPI) and the Producer Price Index (PPI) are the most commonly known indexes. The problem with using these indexes in DOD economic analysis is that they do not apply very well to Defense expenditures. These and most other available indexes are unsuitable because they do not include a sufficient cross section of military items.

However, there are other special indexes and techniques which can be used or developed for use in predicting inflation for economic analysis. The Office of the Secretary of Defense (Comptroller) regularly disseminates cost escalation projections for military construction and family housing; research, development, test, and evaluation (RDT&E); and other major areas of procurement. The DOD Comptroller also compiles a personal pay index which includes both military and civil service compensation. Other indexes can be derived for component subgroups of available indexes compiled by the Bureau of Labor Statistics. Whatever their source, officially disseminated cost projections should not be construed as anything more than a general guideline. Where available, specific local data may be used to establish a more realistic cost model. All sources should of course be explicitly documented.

ESTIMATION OF INFLATION

Once a method of measuring inflation has been established, a major problem is posed in determining what rate to use since economic analyses are comparisons of future costs and benefits. Forecasting future inflation rates can be accomplished in several ways. One method is to forecast that the current rate will continue in the future. This method will yield credible estimates if the current rate and the rate which has been experienced in the recent past are relatively constant. If the trend in recent inflation rates has been significantly increasing or decreasing, a forecast that the current rate will continue is suspect.

Another method of estimating the future rates, which will alleviate some of the problems of forecasting a continuance of the current rate, is to project the future on the basis of a regression analysis of past rates. This is accomplished through the method of Least Squares. Estimation of future inflation rates by linear regression assumes that the future

will be the same as the past. The more historical the data points used, the more the trend will average out deviations, (e.g., the double digit inflation rate experienced in 1973 and 1974 will be offset by lower rates in other years).

A third method of estimating future rates, which does not assume a linear correlation with time alone, is the use of econometric models. These models attempt to find those factors which cause inflation and to establish their mathematical relationship with inflation. Factors generally incorporated in econometric models include: unit labor costs; material input costs; and excess demand variables (such as unfilled orders, capital utilization rate or inventory/sales ratio). Building such a model requires the expertise of a trained econometrician.

What method should be used? A practical solution is to use a combination of methods (i.e., introduce a range of inflated costs in the analysis using two or more of the foregoing methods).

CHAPTER 5

COST-ESTIMATING TECHNIQUES

INTRODUCTION

The adequacy or success of costing efforts depends primarily on the ability of the analyst to establish relationships between the attributes and the elements of a proposal. The selection of cost estimating techniques depends upon such factors as the amount and detail of available data and the time and resources available to develop the cost estimate. Four cost estimating techniques are discussed below: industrial engineering, parametric cost estimating, analogy and delphi estimating. The required level of effort and knowledge associated with these procedures ranges from intuition to extreme detail depending on the complexity of the estimate and the estimating techniques used.

INDUSTRIAL ENGINEERING METHOD

The industrial engineering method is the most sophisticated approach for estimating costs. This approach consists of a consolidation of estimates from various separate work segments into a total project estimate. It is sometimes called the "bottom-up" process because it involves the separation of the total end product (whether hardware or software) into simple parts for which detailed estimates can be established. For example, the estimated cost of producing a new model "widget," which requires a work contribution from 10 separate work divisions in an organization, could well be the summation of 10 separate detailed estimates. Each of the 10 estimates might be composed of several subestimates.

The detailed estimate for each of the work contribution areas is developed by one or more of the following:

1. Examination of historical data for similar items.

2. Establishment of new standards by reviewing current operations (using industrial engineering techniques such as work measurement, time and motion studies, sampling).

3. Engineering simulation of operations required to produce the item.

The end result is the consolidation of the individual estimates into a total projected cost for the system/product.

An advantage of this method is that it separates the parts of the system on which little data are available and permits them to receive special treatment. The industrial engineering approach can result in extremely detailed and

complete estimates of item/system costs. Where detailed data exist, the industrial engineering method is the best method for estimating costs.

PARAMETRIC COST ESTIMATING METHOD

When adequate data is unavailable for employing the industrial engineering approach, the analyst may turn to the parametric cost estimating method. Here, the analyst, is concerned with what the proposal is supposed to accomplish. The yield or benefits of the proposal form the bases (or "parameters") for the cost estimates.

Once these bases are established, the analyst seeks a relationship between the parameters and their costs, the relationships are generally developed from historical data. If the past data is from a single experience, the extrapolation to the proposal may be of questionable value. This data foundation becomes firm as experience with similar systems increases.

Inasmuch as parametric estimates are based on this past experience, costs due to problems inherent in system development are included. Questions regarding unanticipated delays due to technical problems, redefined requirements, and midstream changes are resolved by the inclusion of these expenses in the historical data.

The primary limitation of parametric costing lies in the cost data that are available. Also, as the variation of new systems from previous systems increases, the credibility of the estimate decreases. Parametric cost estimating is the preferred procedure to use in deriving a cost estimate at the earliest stages of development. At this time, the system cost can only be based on expected physical and performance characteristics and their relationship to costs.

For example, the family contemplating the purchase of a new house might consider the following parameters (among others):

Number of bedrooms (2, 3, 4 or more).

Number of baths (1, 1-1/2, 2, 2-1/2 or more).

Number of dens (0 or 1).

Number of finished family rooms (0 or 1).

Capacity of the garage (0, 1, or 2 cars).

Size of property lot (in acres).

Age of the house (in years).

If a house price for any particular combination of these parameters is known (say, the expected selling price of the house currently occupied by the family), then prices for other parameter mixes may be estimated relative to this baseline.

The results of a parametric estimate depend directly upon the ability to establish relationships between the parameters and cost.

ANALOGY METHOD

In situations where there are no qualified cost analysts and little historical data, the entire effort must consist of an application of judgment. A special method of judgment is the use of analogies. An analogy is a direct comparison with similar, historical systems/products. (Although this is probably the most widely used method of estimating costs, it is not really the most accurate.) A major caution with this process is that it is essentially a judgment process, requiring a great amount of expertise and intuitive reasoning. There are two types of analogies: similar products and similar concepts. The first can be represented by the use of commercial airplane costs to estimate cost of military aircraft. An example of similar concepts is the use of aircraft costs to estimate missile costs.

DELPHI METHOD

The delphi method is a way of using expert opinion to arrive at a forecast or estimate by subjecting the views of the individual experts to each others criticism in ways that avoid face to face confrontation and provide anonymity of opinions and of arguments in defense of these opinions.

In one version of this technique, direct debate is replaced by the interchange of information and opinion through a carefully designed sequence of questionnaires. The participants are asked not only to give their opinions but reasons for these opinions, and at each successive interrogation they are given new and refined information, in the form of opinion feedback, which is derived by computed consensus from the earlier parts of the program. The process continues until further progress toward a consensus appears to be negligible. The conflicting views are then documented.

The principal drawback of this technique is that it is cumbersome. Several weeks may elapse before questionnaires are returned or an interviewer can poll the panel. The amount of material to be processed by each respondent for each round may be considerable, and because of the lapse of time the

respondent may have difficulty reproducing his earlier reasoning. And those who are running the process have their own difficulties with digesting and collating a formidable amount of material.

CHAPTER 6

BENEFIT QUANTIFICATION

INTRODUCTION

Benefits are the outputs expected for costs incurred. The term "benefits" in this usage is synonymous with results, utility, effectiveness, or performance. Because costs relate to inputs, not outputs, reductions in costs are not considered benefits. The purpose of benefit analysis is to present to the decision-maker an orderly, comprehensive and meaningful display of all returns expected, for each alternative within the scope of the economic analysis under consideration. As might be expected, benefits are more difficult to quantify than costs. The reason is that benefits tend to have more intangibles. In most instances there is no simple common denominator such as dollars in the case of costs. If a common denominator is not available, returns should be ranked according to some hierarchy of values so that a more rational choice of alternatives can be made.

The analyst must approach the problem of benefit analysis in a manner applicable to the situation but should basically use a three step methodology.

1. Determine, list, and define the relevant benefits.

2. Identify the sources of information.

3. Devise a system for measuring the benefits.

In addition to benefits, the analyst should also include information concerning any negative aspects of alternatives, quantified wherever possible. This information is important to the decision-maker and may be a determining factor in deciding between possible investment alternatives.

STEP I - DETERMINE, LIST, AND DEFINE RELEVANT BENEFITS

This step involves determining the benefits for each alternative - whether the benefit is thought to be potentially quantifiable or not quantifiable. The analyst should list all benefits which may possibly shed light on the economic analysis alternatives. It is quite possible that some of the benefits listed in this first go-round will eventually be discarded and others will become evident further on in the analysis. A full description of each benefit should be given in relation to its respective alternative in the economic analysis.

The benefits expected of any alternative may fall into various "categories" depending upon the kind of program,

system, operation, organization, etc., being analyzed. Terminology used for these categories is generally descriptive of the benefits included. Following is a guide list of categories to be used by the analyst in his effort to include all benefits related to an alternative. The list is not intended to be all inclusive; it is only illustrative of some of the types of benefit categories that could be applicable depending on the problem. Some of the categories under which benefits appear are:

1. Production. Number of commodities or items produced for each alternative (e.g., number of meals served, components manufactured). This could be related to comparable time periods of the economic analysis.

2. Productivity. (Related to staffing benefits) Number of items per productive man-hour, volume of output related to man-hours.

3. Operating Efficiency. At what rate does the system consume resources to achieve its output (e.g., miles per gallon, copies per kilowatt hour)?

4. Reliability. This describes the system in terms of its probable failure rate. Useful measures may be mean-time-between-failure, the number of service calls per year, percent refusals per warehouse request.

5. Accuracy. What is the error rate? It may be possible to measure errors per operating time period, the number of errors per card punched, errors per hundred records, errors per 100 items produced.

6. Maintainability/Controllability. Has adequate human engineering been performed? Is the system compatible with adequately trained "crew" members? When the system does fail, is it difficult to repair because of poor accessability? A useful measure could be based on the average number of manhours necessary for repairs over a given time period, "downtime," or the crew size necessary to control and maintain the system.

7. Manageability. Consider how the workload of the organization will be affected by increased or decreased supervision or inspection time as a result of the system. Man-days could be used as a measure; difference in kind of personnel might be a factor as well as availability of type needed.

8. Integratability. Consider how the workload and product of the organization will be affected by the changes necessitated in modification of existing facilities or equipment, technical data requirements, initial personnel training, warehouse space for raw goods or parts storage.

9. Availability. When can each system be delivered/ implemented; when is it needed to meet proposed output schedules? What is the lead time for spare parts delivery?

10. Service Life. Consider how long the proposed system will affect the organization's workload or output. What about obsolescence?

11. Quality. Will a better quality product/service be obtained? Could quality be graded, thus measurable? If not, a description of improvement could be given. What is the impact of varied quality?

12. Acceptability. Consider the alternative in terms of whether it may interfere with the operation for parallel organizations or the operation or prerogatives of higher echelon organizations.

13. Ecology. Consider the ecological aspects of each alternative. What are the current legislative requirements?

14. Economic. Consider employment benefits, DOD small business obligations, economically depressed area realtionships, legislative requirements.

15. Morale. Employee morale. This could be measured by an opinion sample survey.

16. Safety. Number of accidents, hazards involved.

17. Security. Is security built in? Will more precautions be needed? More guards? Are thefts more likely?

Pertinent benefit categories will become evident as the analysis of the alternatives is performed. The benefits, of course, should be defined and described for each alternative under review.

An example of one analyst's initial listing of benefits for contracting a computer programming requirement to an established programming firm as opposed to establishing a new in-house capability is shown in Table 6-1.

TABLE 6-1

BENEFITS

CONTRACT	IN-HOUSE
1. Fewer programming errors.	1. Instant de-bugging if required.
2. No training required.	2. Shorter turn-around time.
3. Known costs.	3. Simplified communication.
4. No equipment maintenance (and other logistic support).	4. Decreased transmittal effort.
5. Minimum personnel problems.	5. Immediate availability once established.
6. Increased experience and capability for future expanded effort.	6. Improved management control.
7. Greater capability for handling varying workload.	7. Provides training capability.
	8. Increased understanding of agency problems.
	9. Greater capability to change mission direction.

STEP II - IDENTIFY SOURCES OF INFORMATION FOR BENEFIT DETERMINATION

For each benefit listed, the analyst should identify: (1) the source of information, (2) in what form it is available, and (3) how he proposes to gather the needed information and the feasibility of doing so. Sources of information should apply to benefits which may be quantifiable as well as those which do not seem quantifiable. In estimating parameters it is best to obtain the maximum amount of information. Should the analyst decide that obtaining the needed information is impractical, for whatever reason, he should be able to support his position.

STEP III - DEVISE A SYSTEM FOR MEASURING BENEFITS

The third step is to devise a measurement system for the output of each alternative. Such measurement can vary from precise quantities of physical output for the more tangible

benefits to general narrative descriptions for the intangibles as discussed below.

QUANTIFIABLE OUTPUT MEASURES

Economic analysis is most effectively applied where output can be defined in terms of physical yield. Each analysis will possess its own measure of effectiveness. In fact, there may be any number of different measures. For example, reduced pollution can probably be stated in some quantifiable terms, such as gallons of effluence per hour. Decreased procurement leadtime could be given in days, or in changes in inventory levels. In citing increased safety as a benefit, one could state the number of employees exposed to the dangers for each of the proposed alternatives.

If precise quantification of benefits is impossible, perhaps a relationship can be established among the alternatives. The benefits of one may be expressed in the form of an index and all others related to it. Or perhaps a selected alternative can be used in developing ratios with the other alternatives.

As quantification of benefits becomes less feasible, ranking must be accomplished on a more subjective basis. This may consist of simple numerical listing in order of preference, with the alternative's position in the list not indicating any particular level of benefits. Or a verbal scale may be used in which alternatives are described by using adjectives to indicate their relationships (e.g., "excellent, good, poor"). These measurements are useful but are less precise than those mentioned above.

NONQUANTIFIABLE OUTPUT MEASURES

Despite the analyst's best efforts to develop quantitative measures of benefits, he sometimes is faced with a situation which simply does not lend itself to such analysis. Certain projects may provide nontangible benefits such as improved morale, better community relations, and other similar qualitative advantages. Although they are more difficult to assess, these benefits should be documented and portrayed in the economic analysis.

In most such instances the analyst must resort to written qualitative benefit descriptions. This is the least preferable method of analyzing benefits due to its inherent lack of precison. However, under certain conditions this method must suffice, and if the following guidelines are observed, qualitative statements can make a positive contribution:

1. Identify all benefits attendent to each alternative under consideration. Give complete details.

2. Identify benefits common in kind but not in extent or degree among alternatives. Explain differences in detail.

3. Avoid platitudes. All prospective projects are normally worthwhile in that they support national defense, and statements to this effect are unnecessary. Platitudinous statements serve only to cloud the decision-making environment.

BENEFIT ANALYSIS PITFALLS

To complete the picture, it is appropriate to briefly examine some of the more common pitfalls in benefit analysis, which is considered the weakest area in most economic analyses. The first is to confuse benefits and cost savings. This error has a history of occurrence in ADP analyses, probably because ADP people think of their systems as a means of cutting costs. Cost savings, the difference in cost between one alternative and another, may well be the basis for decision, but, they should not be confused with the output, product, or benefit of a course of action. The cost savings is reflected in the differential cost of alternatives. It does not belong on the benefit side of the equation. The benefit or output should justify the existence of the process; it should reflect the basic mission of the organization. Accordingly, it follows that, if cost savings is a benefit, then cost savings is the reason for the existence of the system and the greatest cost savings can be achieved by eliminating the entire system. The benefit must be found in the product or service of the ADP system.

Another common error, and it may be a deliberate error, is the "equal benefits" escape clause. One way of avoiding the problem of benefit measurement is to set the benefits equal and use least cost analysis. To establish equal benefits, the analyst, and more importantly, his decision maker must be indifferent to the benefits offered by the alternatives.

If the decision maker is not indifferent, because there are significant differences between the benefits offered by alternative courses of action, the least cost recommendation may well be subjected to a good deal of fire.

An example of this sort of problem is the argument that analysis is a faulty procedure because it always recommends a modified or rebuilt system instead of the development of a new system. If the two alternatives offer equal benefits (production rate, reliability, responsiveness) the study is quite proper in recommending a modified or rebuilt system. However, if it can be shown that the new system offers a significant upgrade of capabilities, the least cost criteria is at fault. Use of the unequal cost/equal benefit criteria would enable the analyst to identify the increased capability and the cost of such increase. The decision maker would then be

faced with an evaluation of the increased cost against the increased capability.

When measuring benefits, most analysts at one time or another fall into the error of using spurious measures. In the search for something to count or to measure and record, we often seize ancillary or independent activities, because they have a tangible, easily identified product. Once they are highlighted and used by management to measure performance, they become the dominant factor at the expense of proper mission accomplishment.

Another error is worth highlighting. This is the omission of quality control. An unequivocal description or a set of specifications is necessary, if we are to insure that a productivity increase or a cost reduction is not accomplished at the expense of quality and usefulness. The obvious example of inferior products of a tangible nature come quickly to mind.

The final error is quantification at any cost. There are valid ways of measuring almost all benefits, if we can justify the resources required for the task. Quantification, if only in a ratio or an order of desirability is a most useful characteristic and should be sought, but only within the parameters of resources and of validity and accuracy. Inaccurate quantified measures can do more harm than good, by leading the decision-maker to a decision he would normally reject.

Part III

Investment Concepts

CHAPTER 7

ECONOMIC LIFE AND PROJECT LIFE

INTRODUCTION

In Chapter 1, economic analysis was defined as a method of approaching the problem of choice. A fundamental choice that faces the decision maker is whether to spend more money today and less tomorrow or less now and more in some future period of time. Before a choice can be made, one must first determine how far into the future the period should extend, that is, the appropriate time period of the economic analysis must be established. Once this is determined, the analyst can proceed in developing cost streams for each alternative.

ECONOMIC LIFE

Economic life is defined as that period of time over which the savings or benefits to be gained from a project may reasonably be expected to accrue.

The economic life will ultimately be governed by one of three factors:

1. The Mission Life is that period of time over which a need for the asset or program is anticipated. (For example, an incoming college freshman has decided to purchase a used car for commuting to and from school. Since his grandfather has promised him a new car upon graduation from college he will need the used car only during his remaining time in school. Thus, the mission life of the car is four years.)

2. The Physical Life is the period during which a facility or piece of equipment will be available for use before it is exhausted in a physical sense, that is, decayed or deteriorated. The physical life of an asset may vary from project to project depending upon usage. (The college student has looked at a number of used cars. One of the cars he is considering is fairly new and has been well maintained. Its expected physical life is six years.)

3. The Technological Life is the period of time before which improved technology would make an asset obsolete. (Since the car described above is fairly new, gets good gas mileage and meets all current federal polution and safety requirements its technological life is estimated to be ten years.)

The economic life will generally be the shortest of the mission, physical or technological lives. In the above example the economic life is four years. Note, that due to planning horizon limitations it is recommended that economic lives in excess of 30 years not be used in analyses. Moreover, due to discounting, streams existing beyond 30 years have little effect.

LEADTIME AND PROJECT LIFE

Investments sometimes occur several years prior to the time that the project starts providing benefits. This period of elapsed time between initial funding or date of decision and the commencement of the economic life is referred to as leadtime. The leadtime together with the economic life comprise what is known as the project life.

CASH-FLOW DIAGRAMS

Project life costs can be depicted diagramatically through the use of cash-flow diagrams. The cash-flow diagram is a pictorial technique for representing the magnitudes and timing of all costs associated with the alternative. It is customary to draw a cash-flow diagram for each alternative being considered in the economic analysis. The first step in construction is the drawing of a horizontal line to illustrate the entire time period to be considered. The line is then divided into equal time periods. Each time period is numbered chronologically. Illustration of cash-flows is accomplished through use of vertical lines with arrowheads.

Outflows and inflows are differentiated by direction of the arrowheads. Downward pointing arrows indicate cash outflows (costs), while upward pointing arrows indicate cash inflows (receipts).

Figure 7-1 illustrates a project with an economic life of seven years. An initial investment expenditure of $10,000 occurs at "time zero" (right now) and recurring costs of $2,000 are incurred during each succeeding period. Receipts of $1,000 represent terminal value at the end of the seventh period.

CASH FLOW DIAGRAM

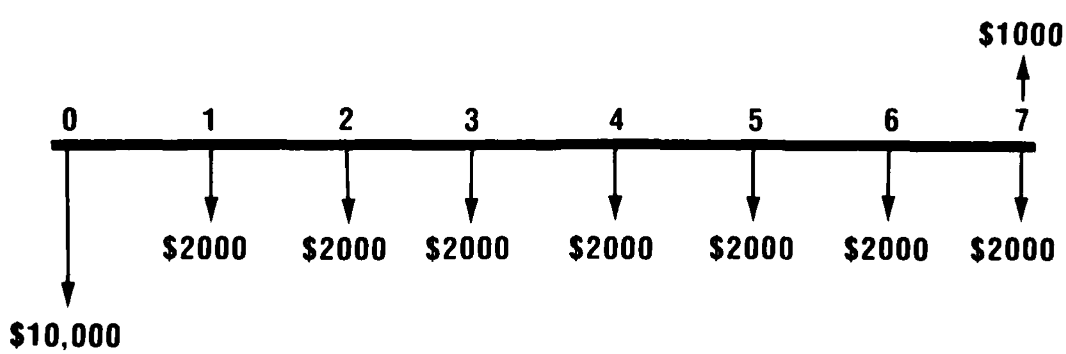


Figure 7-1

When leadtime is considered part of the project life, the cash-flow diagram will be somewhat altered. Figure 7-2 shows an alternative requiring research and development for a 2-year period. When the alternative becomes operational in the third year, its economic life begins. The economic life is 7 years with annual costs of $3000. The leadtime for this project is shown with dashed lines to indicate that it is not part of the economic life.

CASH FLOW DIAGRAM - - WITH LEADTIME

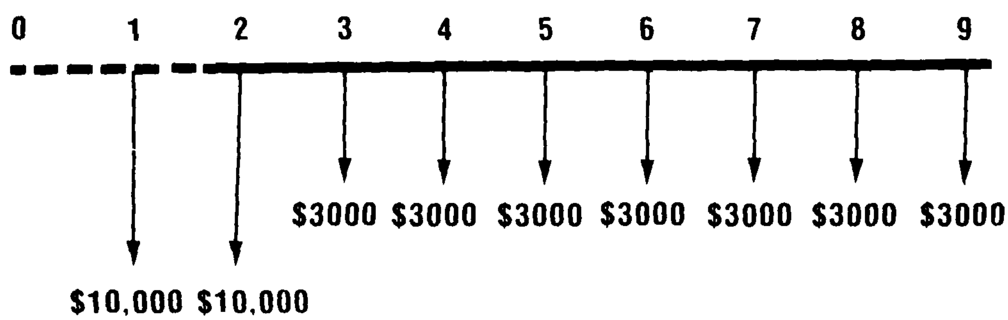


Figure 7-2

NOTE: Although the cash flows are represented as occurring at the ends of years, they are presumed to have occurred at some time during (or throughout) their respective years. This convention will be adhered to throughout this manual.

PERIOD OF COMPARISON

Once the economic and project lives of each alternative are ascertained, the analyst must determine over which period to compare the alternatives. Generally, the period of time for comparison should be set so that alternatives start yielding benefits during the same year.

Because the economic lives and leadtime can vary among alternatives, DOD has established the following guidelines for determining the period of comparison:

1. Same Economic Lives and Leadtimes. If both the economic lives and leadtimes for all alternatives are the same, there is no problem, the analyst will compute alternatives over the same project life. For example, given alternatives A and B in Figure 7-3, the period of comparison in the analysis will be 8 years.

CASHFLOW DIAGRAM - - SAME ECONOMIC LIVES AND LEADTIMES

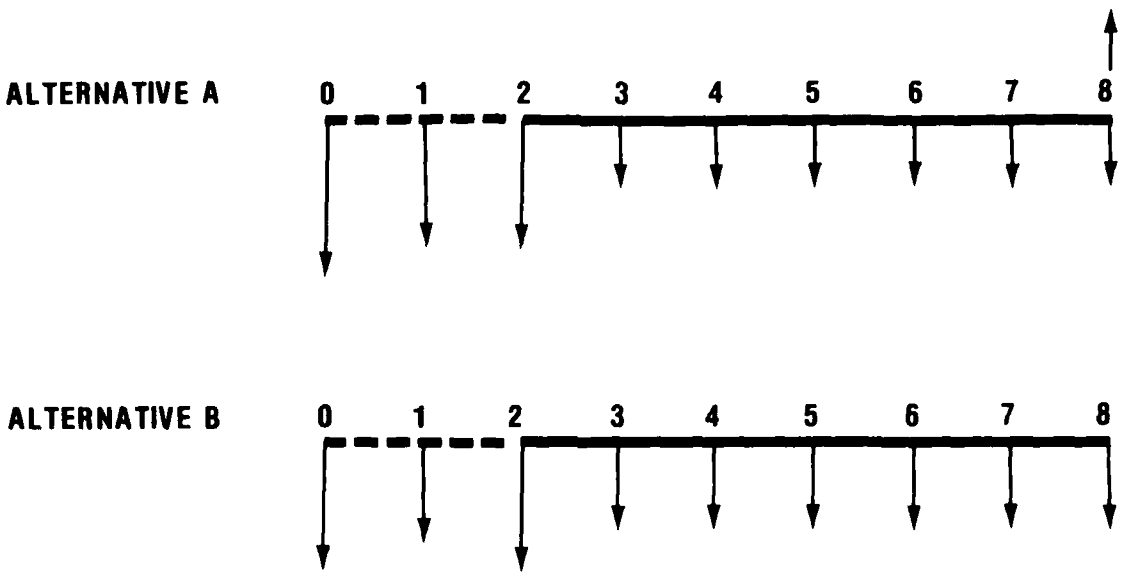


Figure 7-3

2. Same Economic Lives/Different Leadtimes. If alternatives have the same economic lives, but different leadtimes the first year in which expenditures will have to be made for any one of the alternatives should be considered the base year or "project year 1" for all the alternatives. For example, suppose there are two alternative ways of automating a manual accounting system. The economic lives of both alternatives are the same, however, the lead times differ. Alternative A requires a three year lead time to develop the system before it can become operational. Alternative B requires only two years for development. In this case the base year for the two alternatives corresponds to the starting year for Alternative A, and Alternative B has zero costs for that year. This method of evaluation imposes an appropriate opportunity cost for the capital required to finance the alternative which requires earlier funding. The cash-flow diagrams for the two alternatives are shown in Figure 7-4.

CASHFLOW DIAGRAM
SAME ECONOMIC LIVES AND DIFFERENT LEADTIMES

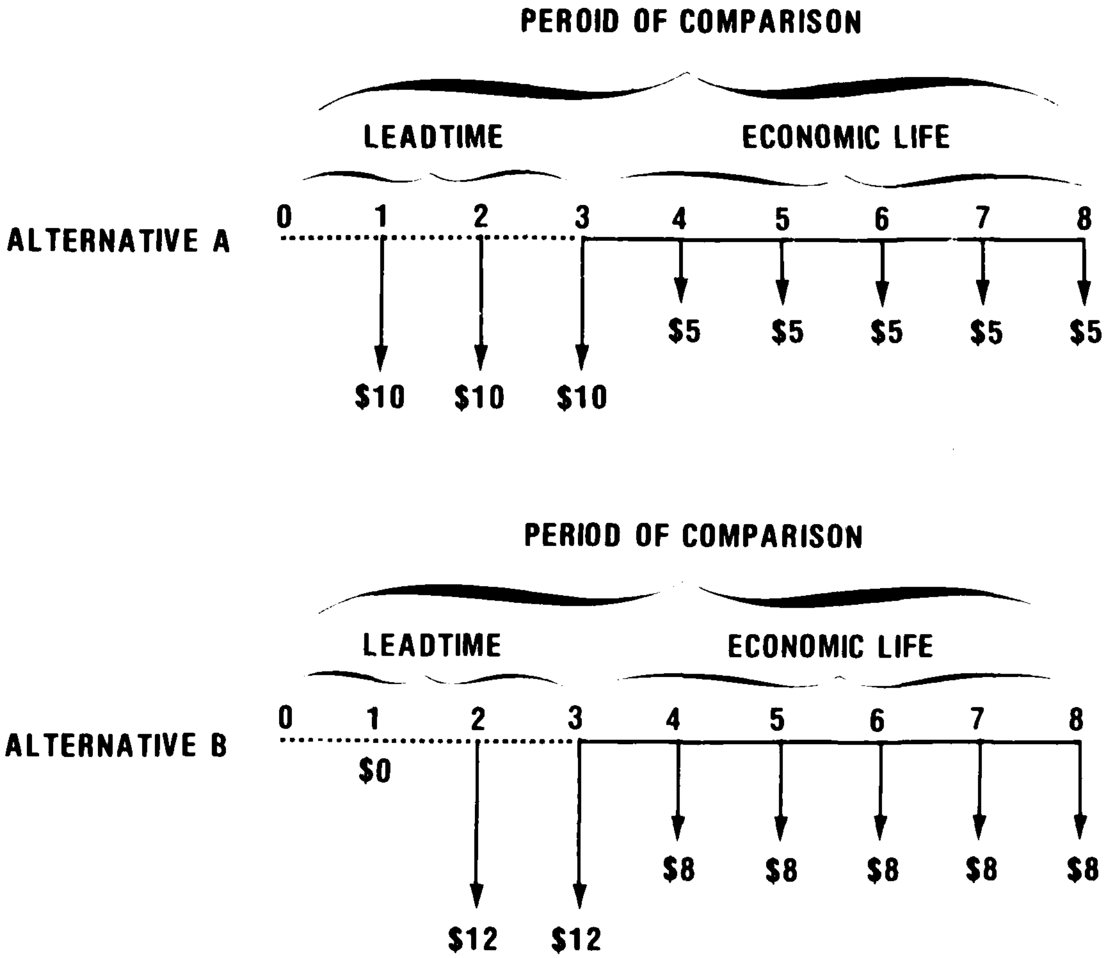


Figure 7-4

3. <u>Different Economic Lives</u>. When the economic lives of the alternatives are different the problem can be handled in one of several ways. The first is to let the economic life of the dominant asset prevail with subsidiary assets being replaced as necessary. The second method is to use the shortest economic life and impute residual value to the asset with the longer life. Suppose, for example, that a certain objective can be achieved by using either Machine A or Machine B, whose economic lives are six years and three years, respectively. If the first method is employed, the analysis will be costed over six years. At the end of three years Machine B will have to be replaced by another similar machine. Costs for the two alternatives are shown in Figure 7-5.

If the second method is used the analysis will be costed over a period of three years. Residual value for Machine A will be shown at the end of the third year. This method is shown in Figure 7-6.

A third method of comparing alternatives with unequal economic lives is to use the Uniform Annual cost technique. This method is detailed in Chapter 11.

CASHFLOW DIAGRAM
ANALYSIS BASED ON LIFE OF DOMINANT ASSET

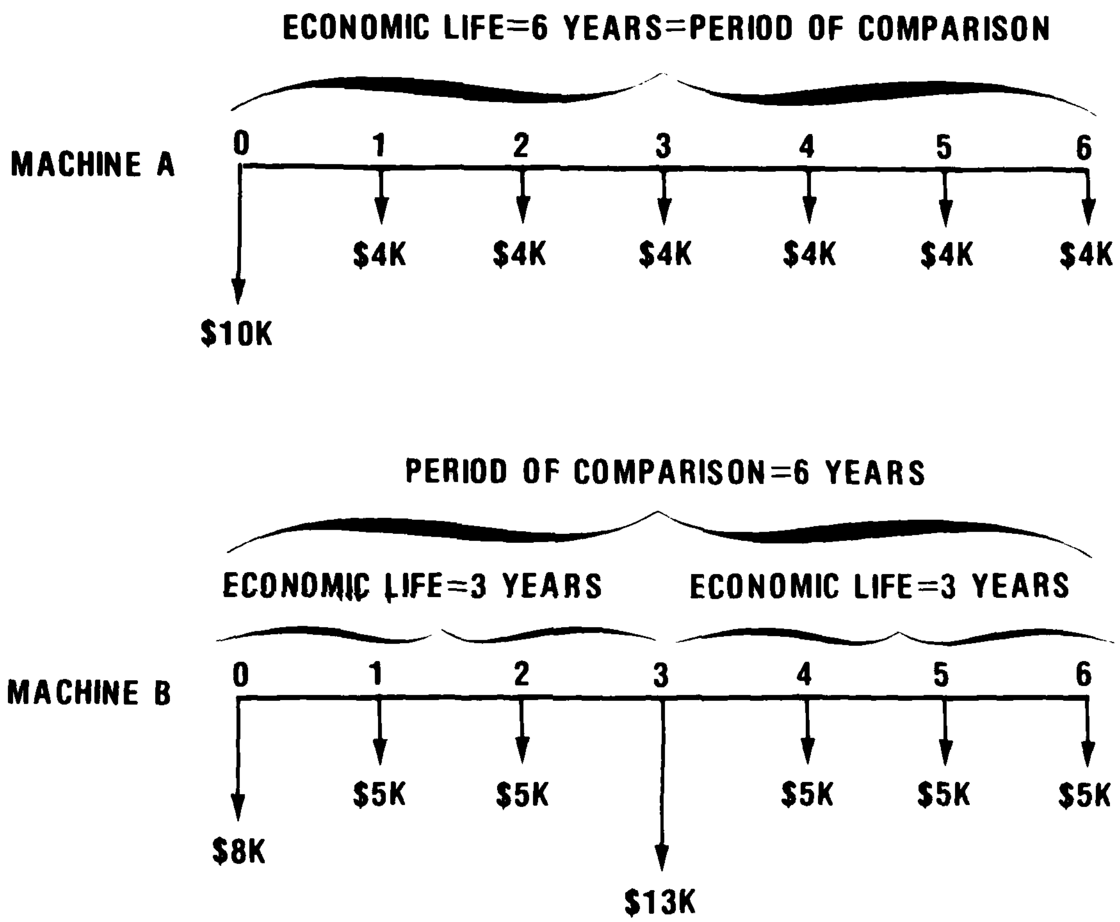


Figure 7-5

CASHFLOW DIAGRAM
ANALYSIS BASED ON ASSET WITH SHORTER LIFE

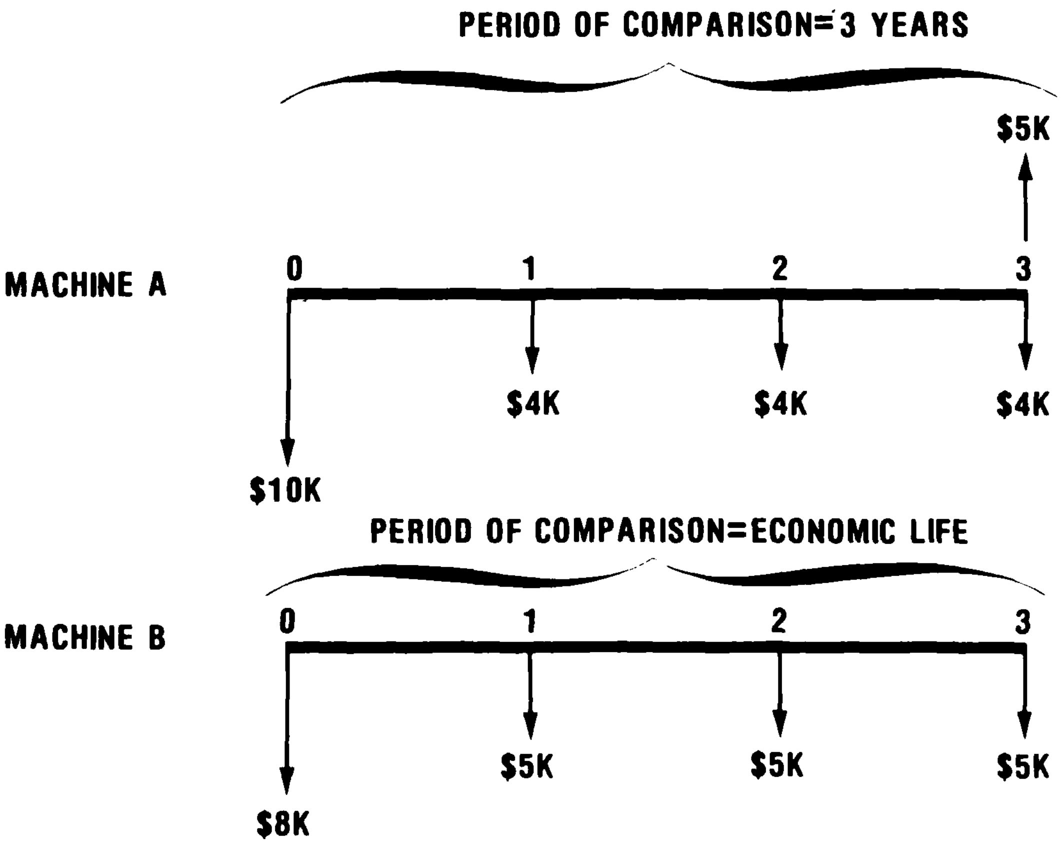


Figure 7-6

CHAPTER 8

THE NOTION OF PRESENT VALUE

INTRODUCTION

Money, like other goods and services, is a marketable commodity. Its use can be bought and sold in the marketplace. The price it commands is generally referred to as interest. The existence of interest can be explained by examining both the supply and the demand situations for money. By supplying money to another, one deprives himself of immediate satisfaction; that is, he cannot use his money to buy consumer goods now (e.g., color T.V., new car). The greater the fee received by the lender, or the higher the interest rate, the greater the motive for putting off consumption in order to earn a return on invested money. It is reasonable to believe that if the return on invested capital were removed, investment would be nonexistent.

On the demand side, it is sometimes profitable for business enterprises to borrow money and pay the interest and fees required by the lender. The reason this may be profitable is that capital goods such as engineering equipment, machines, and structures are productive; that is, they return more than they cost.

SIMPLE INTEREST

The interest rate is customarily expressed as a precent or decimal, representing the fractional amount of a loan the borrower must pay the lender within a specified interval of time. The amount of interest I is determined by multiplying the principal P by the rate of interest i. This may be expressed through the simple interest formula:

$$I = P * i$$

COMPOUND INTEREST -- ONE YEAR

Interest and principal are calculated for most accounts on a compound basis. Compound interest is the result of adding interest to principal in each period before calculating the interest on the new principal for the next period.

Suppose an amount of money P is lent today at an annual interest rate i. At the end of the year the borrower will have to return to the lender not only the original amount P but the additional amount I. Thus the total future amount F_1 due becomes:

$$
\begin{aligned}
F_1 &= P + I \\
&= P + (P * i) \\
&= P(1 + i)
\end{aligned}
$$

Example 8-1

Assume that a potential borrower wishes to borrow $1,000. If the interest rate is 6%, what will be the amount due to the lender one year from now?

Solution

$$P = \$1{,}000, \qquad i = 6\%$$

$$F_1 = P(1 + i)$$

$$F_1 = \$1{,}000(1.06) = \underline{\$1{,}060}$$

COMPOUND INTEREST -- TWO YEARS

Suppose that a loan is to be repaid at the end of two years instead of one. The amount F_1 that would have been paid at the end of Year 1 becomes the principal during the second year.

$$
\begin{aligned}
F_2 &= P(1 + i) + i(P(1 + i)) \\
&= P(1 + i)(1 + i) \\
&= P(1 + i)^2
\end{aligned}
$$

Example 8-2

Assume that $1,000 is again borrowed at a 6% interest rate. However, this time the loan is made for a two-year period. What amount must be repaid when the loan becomes due?

Solution

$$P = \$1{,}000, \qquad i = 6\%$$

$$
\begin{aligned}
F_2 &= P(1 + i)^2 \\
&= \$1{,}000(1.06)^2 \\
&= \$1{,}000(1.1236) \\
&= \underline{\$1{,}123.60}
\end{aligned}
$$

COMPOUND INTEREST -- n YEARS

The only difference between the expression for one year and the expression for two years is the addition of an exponent. It can be shown through successive repetition of the above reasoning that if an amount P is lent today at an

annual interest i the total amount repaid to the lender by the borrower at the end of n years is:

$$F_n = P(1 + i)^n$$

THE CONCEPT OF PRESENT VALUE

The fact that banks pay interest on deposits and people, businesses, and government rent money, is evidence that a given amount of money is worth more today than the same amount a year from now[1]. That is, if you have a choice of receiving $1,000 in cash now or $1,000 in cash ten years from now, there is little question of your selection. By accepting the $1,000 now, you could, through careful investment, have considerably more than $1,000 in ten years. The same principle applies to outflows of cash. Obviously, you would rather pay out $1,000 ten years from now than pay out $1,000 now. Because of this "time value of money" some procedure must be adopted in order to evaluate future cash flows in terms of today's money, or its "present value."

The procedure recommended by both economists and businessmen for accomplishing this common-time-basis adjustment is known as "discounting." Discounting is the inverse of compounding. Whereas, in compounding one moves from the present into the future, in discounting the movement is from the future back to the present.

The relationship of a single current amount of money and its future equivalent was shown above to be $F_n = P(1 + i)^n$. Algebraic manipulation will convert this formula into its inverse relationship. Thus, the formula used in discounting becomes:

$$P = F_n * \frac{1}{(1 + i)^n}$$

P now stands for present value, but it is the same as principal in the compound interest formula.

Frequently when money is borrowed a modified form of discounting is used to determine the cost to the borrower and the amount that is received. Whenever interest is paid in advance, the amount borrowed has been discounted. For example, if you receive $940 but agree to pay $1,000 back at the end of 1 year, the $1,000 has been discounted at 6 percent. The actual interest that you have paid on the amount that you received, $940, is 6.4 percent. You would have been charged 6 percent interest if you had received $1,000 and paid back

[1]Please note this has nothing to do with inflation, banks pay interest and people borrow money even in a depression.

$1,060 at the end of the year.

Example 8-3

A grandfather wishes to establish a trust account for his new grandchild. If the interest rate on the trust fund is 4%, how much must the initial deposit be in order to present the child with $5,000 on his 21st birthday?

Solution

$$F_n = \$5{,}000 \quad i = 4\% \quad n = 21$$

$$P = F_n * \frac{1}{(1 + i)^n}$$

$$P = \$5{,}000 * \frac{1}{(1.04)^{21}}$$
$$= \$5{,}000(.438834)$$
$$= \underline{\$2{,}194.17}$$

In this example the $5,000 gift twenty-one years from now could be made by setting aside $2,194.17 today. It could be stated that, relative to an interest rate of 4%, the present value of $5,000 twenty-one years from today is $2,194.17.

CHAPTER 9

GOVERNMENT DISCOUNT RATES

INTRODUCTION

The Government recognizes the effect time has on money and has adopted the practice of discounting when evaluting investment projects. In DOD, discounting must be applied whenever the costs or cash benefits of a project would extend over a period of time greater than three years from the project inception date. The prescribed discount rate is 10%. In order to ease the computational task of discounting a number of standard present value tables were developed and are available for general use. Guidance for using these tables is provided in the following pages.

CHOOSING A DISCOUNT RATE

Even when there is little disagreement about the investment's prospective costs and benefits, the choice of the discount rate figure may make the difference between acceptance and rejection. A low discount rate gives little attention to the time value of money. Investment costs incurred during the early years of a project life can be easily offset by benefits achieved in the late years. Thus, a low discount rate would tend to expand the number of public investment projects that appear feasible, thereby causing many public projects with low returns to be undertaken at the expense of more productive investments in the private sector. The net result of this would be to lower the rate of national economic growth.

A high discount rate, on the other hand, would tend to place a greater emphasis on today's costs. Thus, savings achieved in the out-years would have little impact on offsetting investment costs. The net result would be fewer government investments.

The proper criterion on which to judge the desirability of a government project, from the point of view of the general welfare, is the value of the opportunities which the private sector must pass by when resources are withdrawn from that sector. A government project is desirable if, and only if, the value of the net benefits it promises exceeds the cost of the lost productive opportunities which that investment causes. The correct discount rate for the evaluation of a government project is the percentage rate of return that the resources used would otherwise provide in the private sector.

GOVERNMENT DISCOUNT RATE (10%)

The current discount factor to be used in evaluating Government investment is 10%. This rate is endorsed by both DODI 7041.3 and OMB Circular A-94, "Discount Rates to be used in evaluating time-distributed costs and benefits," and is considered to be the most representative overall rate at the present time. It represents an estimate of the average rate of return on private investment before corporate taxes and after adjusting for inflation. Thus, the 10% rate is the weighted average opportunity cost of private spending that is reduced as a result of taking money out of the private sector.

PRESENT VALUE TABLES

The discount factor $1/(1+i)^n$ was developed in the previous chapter. This formula can be applied easily to simple examples where cash-flows occur in the early years of the project. However, when evaluating a more complex project involving cash-flows throughout the entire economic life, the computational task of applying the formula becomes quite tedious. Therefore, it is convenient to prepare a standard list of discount factors for purposes of reference. Using the prescribed 10% rate, such a list is developed in Table 9-1.

TABLE 9-1

PRESENT VALUE - 10% DISCOUNT FACTOR

Years From Today (n)	Present Value Factor
0	$\frac{1}{(1.1)^0} = 1.000$
1	$\frac{1}{(1.1)^1} = 0.909$
2	$\frac{1}{(1.1)^2} = 0.826$
3	$\frac{1}{(1.1)^3} = 0.751$
4	$\frac{1}{(1.1)^4} = 0.683$
5	$\frac{1}{(1.1)^5} = 0.621$

The factors depicted in Table 9-1 are termed "end-ofyear" factors. This title is appropriate because they are derived under the assumption that cash-flows occur precisely at the ends of years. In the real world, this is generally not the case. Costs are usually dispersed throughout the year. Thus, a more realistic discount factor would be one that occurs at some point during the year. DOD currently employs factors which are derived from the standard present value formula and represent an "average" for the year.

Table 9-2 illustrates the conversion from end of year to average factors. A complete list of present value factors for years 1-30 is provided in Table A of Appendix C.

TABLE 9-2

END OF YEAR VS. AVERAGE DISCOUNT FACTORS (10%)

Years	End Of Year Factor	Average Factor
0	1.000	
1	0.909	0.954
2	0.826	0.867
3	0.751	0.788
4	0.683	0.717
5	0.621	0.652

The rationale for using average factors instead of end-of year factors is essentially twofold:

1. After the initial investment cost, most of the annual costs and benefits associated with a project do not occur at a single point in time but rather are spread throughout the year. This is typically true of operating costs and salaries. Such costs are best approximated by an annual lump sum payment occurring in the middle of the year.

2. The exact time of occurrence of costs and benefits in the out-years of an economic life may not be known with certainty. In the absence of more specific information, there is no reason to assume that these costs and benefits will occur only on the anniversaries of acquisition; they might occur at any point in the year. Average factors are generally applied to such costs. Errors on the low side should occur about as often as errors on the high side. In the long run, there will be an offsetting effect.

The following examples demonstrate the use of Table A factors:

Example 9-1

As one alternative in a certain project, NAVDAC is considering leasing additional computer space for a four year period. Annual rental would amount to $10,000. What will be the total discounted cost if this alternative is chosen?

Solution

Table A discount factors are used to determine the present value of this alternative:

$$\begin{aligned} PV &= \$10{,}000(0.954) + \$10{,}000(0.867) + \$10{,}000(0.788) + \\ &\quad \$10{,}000(0.717) \\ &= \$9{,}540 + \$8{,}670 + \$7{,}880 + \$7{,}170 \\ &= \underline{\$33{,}260} \end{aligned}$$

The above calculation can be simplified if the recurring $10,000 is factored from each term. Thus:

$$PV = \$10{,}000(0.954 + 0.867 + 0.788 + 0.717).$$

In effect, all this operation entails is finding the sum of the first four Table A factors and then performing a single multiplication.

To simplify this task even further, a list of cumulative sums of Table A factors has been developed. These sums can be found in Table B of Appendix C. Using Table B, the corresponding cumulative discount factor for the above problem is 3.326. Thus, the present value becomes:

$$PV = \$10{,}000(3.326) = \underline{\$33{,}260}$$

This is exactly the same result obtained earlier using Table A factors.[1]

Example 9-2

NAVSUP is planning to automate one of its management information systems. One of the alternatives being considered has an eight-year life and projected costs as follows:

---

[1]Discrepancies occasionally occur between answers obtained by the Table A method and the Table B method; these are attributable to rounding off error. Table B factors have been computed from a mathematical formula rather than simple addition of Table A factors.

Initial Costs	$35,000
Operating Costs	
Year 1	2,000
Year 2	2,500
Years 3-8	3,000

What will be the discounted cost of the project if this alternative is chosen?

Solution

This problem involves the use of both Table A and Table B. To discount the single amount factors in years 1 and 2, Table A factors must be used. Years 3-8, however, involve a uniform series of costs. For these years, Table B factors may be applied by considering the difference between the 2nd year factor and the 8th year factor. Thus, for this example the cumulative discount factor for years 3-8 is 3.776(5.597 - 1.821).

Therefore, the total present value is:

$$PV = \$35,000 + \$2000(.954) + \$2,500(.867) + \$3,000(3.776)$$
$$= \$35,000 + \$1,908 + \$2,168 + \$11,328 = \underline{\$50,404}$$

Two general rules for the application of cumulative discount factors may be stated as follows:

Rule 1 - To find the present value of a series of uniform recurring cash-flows beginning in year 1 and continuing through year n, multiply the amount of the annual payment by the nth year factor from Table B, Appendix C.

Rule 2 - To find the present value of a series of uniform recurring cash-flows beginning in year m and continuing through year n, multiply the amount of the annual payment by the difference between the factors for year n and year m-1 in Table B, Appendix C.

DISCOUNTING WITH INFLATION

The 10% discount rate implicitly escalates constant dollar cost estimates at a normal rate. Therefore, inflation generally will not be considered in the analyses. However, when it is considered, only a differential rate will be used (i.e., the expected difference between the average long-term rate for the particular cost or cost element and the normal rate).

Once the differential rate has been selected, the analyst may proceed with the inflating and discounting of project costs. Tables are provided in Appendix D which allow both processes to be accomplished in a single operation. There are 16 tables, one for each of the differential inflation rates -5%, -4%, ..., -1%, 0%, 1%, ..., 10%. These percentages are expressed relative to the average or normal rate of future escalation. For example, 2% means an inflation rate 2% <u>higher</u> that the normal rate; -3%, means a rate 3% per year <u>lower</u> than the normal rate; and 0% indicates no deviation at all from the normal rate. (The reader should note that the factors in the 0% table are identical to those of Tables A and B, Appendix C.) In addition to inflating at the indicated differential rate, all factors simultaneously discount at the standard rate of 10%. In using these factors, the analyst (and reviewer) should keep in mind the two functions which they perform: first, escalating costs to a level expected for that point in time, and second, discounting costs to account for the time value of money.

<u>Example 9-3</u>

A particular project being evaluated by NAVDAC has the following costs:

	Year 1	Year 2	Year 3	Year 4	Year 5
Investment					
ADPE		$2,000			
System Development	$300	$ 200			
Site Preparation	$100				
Annual Operating		$ 300	$600	$700	$700

Over the years ADPE costs for this type of hardware have been escalating at a rate which is 3% below the normal rate. This trend is expected to continue in the future. Evaluate the project in terms of its present value.

<u>Solution</u>

The first step in accordance with DOD policy is to perform the analysis in constant dollars. Table 9-3 calculates the present value, assuming no inflation.

TABLE 9-3

PV WITHOUT INFLATION

Year	Costs	Discount Factor	Discounted Costs	Cumulative Discounted Costs
1	$400.0	.954	$381.6	$381.6
2	2500.0	.867	2167.5	2549.1
3	600.0	.788	472.8	3021.9
4	700.0	.717	501.9	3523.8
5	700.0	.652	456.4	3980.2

The PV = $3980.2

The next step is to perform the analysis in terms of current dollars. The differential inflation rate for ADPE is-3%. Using the second year joint inflation/discount rate in Table 3 of Appendix D, the present value for the project is calculated in Table 9-4.

TABLE 9-4

PV WITH -3% INFLATION FOR ADPE

Year	Costs	Discount Factor	Discounted Costs	Cumulative Discounted Costs
1	$400.0	.954	$381.6	$381.6
2	500.0	.867	433.5	815.1
2	2000.0*	.833*	1666.0*	2481.1
3	600.0	.788	472.8	2953.9
4	700.0	.717	501.9	3455.8
5	700.0	.652	456.4	3912.2

PV = $3912.2

*A -3% inflation rate is applied to the ADPE cost.

COMMON MISCONCEPTIONS ABOUT THE 10% RATE

A number of misconceptions have arisen regarding the 10% discount factor. Some of the more common ones are discussed below:

a. The 10% factor is often conceived as a measure of the rate of inflation. Though inflation may have a substantial impact upon any economic analysis, it is most important that its treatment not be confused with discounting. The concepts are similar in that both recognize the future dollars are not worth as much as today's dollar. However, to differentiate the two concepts the analyst should keep in mind that discounting adjusts a given future dollar level to reveal how many dollars today, drawing interest at a given compound rate, would equate the same number of dollars at the given future date (i.e., the present value of future dollars). On the other hand, inflation merely treats the future dollar for anticipated erosion of the purchasing power of today's dollar (a cup of coffee today costs 20 cents, but the same coffee is expected to cost 30 cents in the future).

b. Some argue that discounting is inappropriate because it ignores the reality of inflation. This, however, is not true in the case of the 10% rate prescribed for economic analyses. The 10% rate automatically adjusts for a normal rate of inflation. If, however, inflation is expected to rise above the normal rate, a further adjustment could be made.

c. Some argue that the time value of money should not be considered when evaluating Government investment proposals because the Government has no option of "banking" money to earn a return. An overall budget is set and money not immediately spent on one project is spent on another and in no case would it be invested to earn interest as in the private sector. Here it must be recognized that the "return" implied by the 10% discount rate does not refer to the result of the Government holding money, but rather to the opportunity cost imputed through the transfer of resources from the private to the public sector.

The Federal Government's investment objective should be to maximize the economic well-being of the nation as a whole. This means that effort must be made to maximize the rate of return from invested resources, regardless of whether the investor is private or public. Therefore, in analyzing an investment the Federal Government must consider the return possible if the funds were left in the private sector. That is, what is the cost of money (or the possible return) in the private capital market. This is the conceptual basis for

considering time value of money or capital costs of government expenditures.

d. One school of thought maintains that the discount rate should be determined by and be equal to the rate paid by the Treasury in borrowing money. This concept is built on the premise that if particular projects are to be undertaken using borrowed funds, the minimum rate of return should be based on the rate of cost of those borrowed funds alone. However, this argument proves to be invalid because Government investment is not financed solely through borrowed funds. The majority of revenue is raised through taxation. It is this involuntary transfer of resources from the private sector to the public sector that is used to finance most government investments. Because this money could have been used to finance private investment, it is appropriate that the private sector rate of return be used.

Part IV

Comparison of Alternatives

CHAPTER 10

PRESENT VALUE ANALYSIS

INTRODUCTION

In evaluating alternatives, the best alternative is sometimes apparent by inspection. This is true, for example if the alternatives have equal service lives and one of the alternatives has higher benefits, lower initial costs, lower periodic expenditures, and a higher salvage value--one alternative beats all others in all respects. In most cases, however, all factors do not favor the same alternative. When this is the case, it is necessary to put all the alternatives on a common basis of time and cost to make a valid comparison.

A number of techniques are available for comparing alternatives. Each incorporates the discounting principles described in the previous chapter. The simplest way to compare the alternatives is to perform a present value analysis. To perform a present value analysis, all costs and receipts for each alternative are put in terms of their worth as of the date the comparison is to be made. The alternative having the lowest present value cost is considered the least costly alternative and is recommended to the decision-maker. A present value analysis is an appropriate technique to use whenever the benefits and project lives are the same for all alternatives.

USING PRESENT VALUE ANALYSIS

In order to use present value analysis as the sole basis for decision-making, the following conditions apply.

1. Benefits for all alternatives must be equal. When benefits are not equal the least costly alternative will not necessarily be the best alternative. The best alternative may in fact be the one that costs the most, yet produces a significantly higher level of benefits. Thus, when benefits are unequal the decision should not be based solely on the present value analysis.

2. Service lives of the alternatives must be finite. That is, the intended estimated life of the alternative must be of some finite time. For example, Printer A has been estimated to have a physical life of 6 years. Printer B has an estimated life of 12 years.

3. Service lives of alternatives must be equal, or else they must be placed on equal terms. This can be accomplished

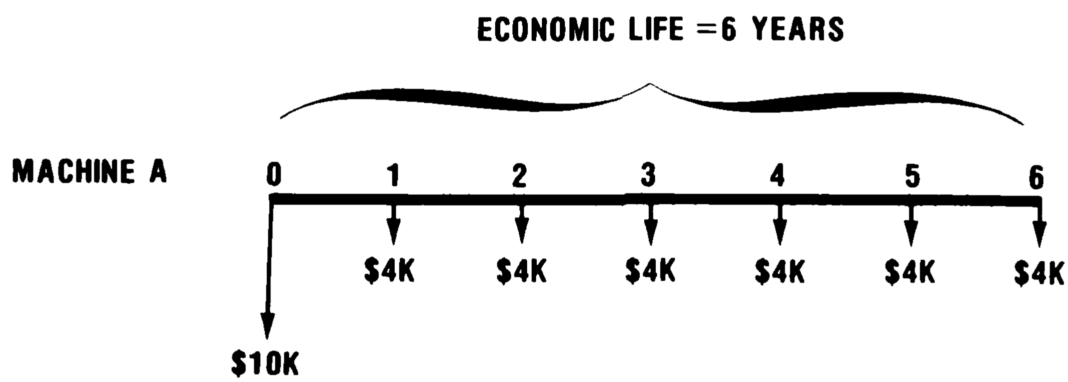
one of two ways. First, by using the common multiple approach. Printer A would be replaced after 6 years so both Alternatives A and B are compared on the 12 year service life base. Second, the alternatives could be compared using the shorter life and inputing the residual value of the asset with the longer life. Thus, in the above example a six year life would be used. At the end of the sixth year the residual value of Printer B would be included in the analysis.

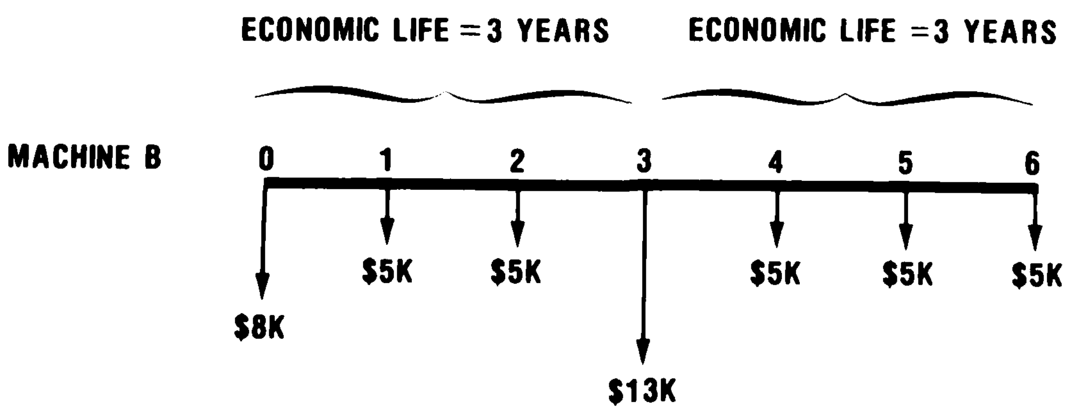
Example 10-1.

Two machines can be purchased to produce the same output. Machine A has an economic life of six years, and costs $10,000 to purchase and $4,000 per year to operate. Machine B has an economic life of 3 years with a purchase price of $8,000 and an annual operating cost of $5,000. Both machines will be worthless at the end of their economic lives. Use present value analysis to determine which machine should be purchased.

Solution

a. Using a six year period of comparison the cash-flow diagrams are:

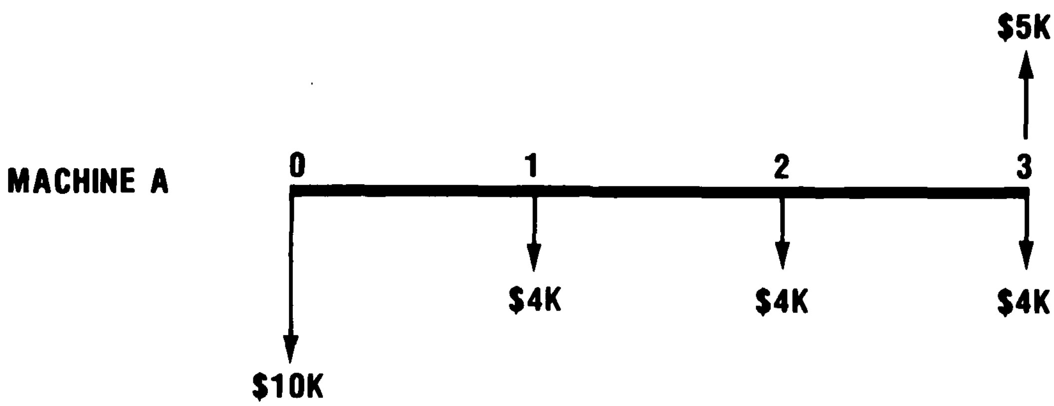


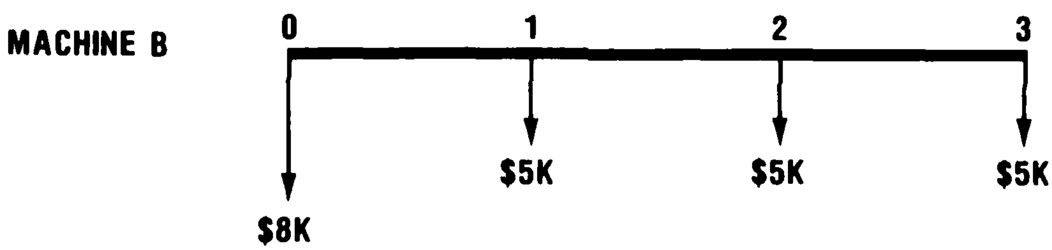


The present value costs are:

PV (A) = \$10,000 + \$4,000 (4.570) = <u>\$28,280</u>
PV (B) = \$8,000 + \$5,000 (4.570) + \$8,000 (.788) = <u>\$37,154</u>

b. If a three year period of comparison were used the present values would have been computed using the following cash-flow diagrams:





The present value of Alternatives A and B for a 3 year period are:

PV (A) = \$10,000 + \$4,000 (2.609) - \$5,000 (.788) = \$16,496
PV (B) = \$8,000 + \$5,000 (2.609) = <u>\$21,045</u>

NOTE: That in both cases Alternative A is the least costly alternative and should be recommended for adoption.

<u>FORMAT FOR PRESENT VALUE ANALYSIS</u>

There is no set format for presenting the results of the present value analysis. Each analyst is free to design a

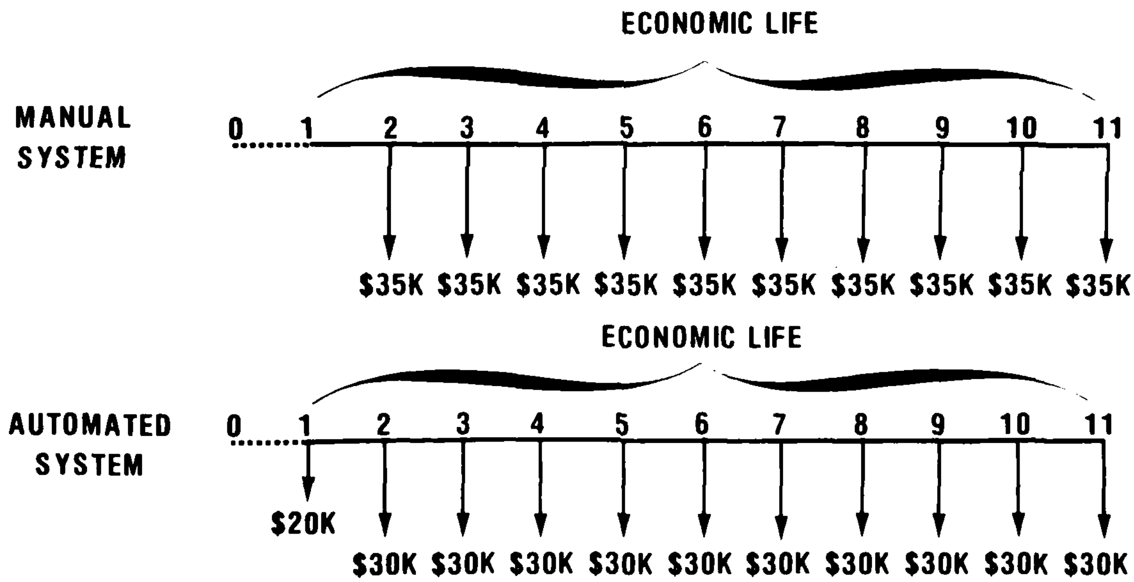
format which will best meet his needs for displaying the data. The only requirement is that the information be organized so the decision-maker can easily identify the discounted costs for each year of the project life. Several sample formats are used in the following examples.

Example 10-2

A Navy office is considering automating its present manual accounting system. System development will cost $20,000 and take one year. Suitable equipment can be leased at an annual rental of $11,000. Maintenance costs are included in the rental. Labor and operating costs will be reduced from a present $35,000 to $19,000 with the new equipment. The economic life of the system is 10 years. Compute the present value of both the manual and automated systems.

Solution

The cash-flow diagrams for the present manual and proposed automated system are shown below:



The present value analysis is presented in Table 10-1. This format is designed to show the differences in costs between a proposed alternative and the current method of operation. A positive difference between the atlernatives will reflect the increased cost over and above today's operation. A negative difference will reflect the savings which will result if the proposed alternative is implemented. In this example

TABLE 10-1

PRESENT VALUE ANALYSIS

($000)

PROJECT YEAR	PRESENT ALTERNATIVE	PROPOSED ALTERNATIVE			DIFFERENTIAL COST/ (SAVINGS)	DISCOUNT FACTOR	DISCOUNTED DIFFERENTIAL COST/ (SAVINGS)	CUMULATIVE DISCOUNTED COST/ (SAVINGS)
		ONE TIME COST	RECURRING COST	TOTAL COST				
1		$20		$20	$20	.954	$19.1	$19.1
2	$35		$30	30	(5)	.867	(4.3)	14.8
3	35		30	30	(5)	.788	(3.9)	10.9
4	35		30	30	(5)	.717	(3.6)	7.3
5	35		30	30	(5)	.652	(3.3)	4.0
6	35		30	30	(5)	.592	(3.0)	1.0
7	35		30	30	(5)	.538	(2.7)	(1.7)
8	35		30	30	(5)	.489	(2.4)	(4.1)
9	35		30	30	(5)	.445	(2.2)	(6.3)
10	35		30	30	(5)	.405	(2.1)	(8.4)
11	35		30	30	(5)	.368	(1.8)	(10.2)

the proposed automated accounting system will yield a net life-cycle savings of $10,200.

Example 10-3

Economic analyses of alternative methods of acquisition must be performed with care and precision. Frequently, the same vendor will not be low on both lease and purchase plans. Four acquisition methods are described below:

Alt. 1 Purchase

a.	Purchase price	$610,000
b.	Annual maintenance of Goverment owned equipment	
	Year 1	$22,300
	Years 2-6	$29,700
c.	Residual value	($122,000)

Alt. 2 Lease to Ownership (title transfer at the end of 6 yrs)

a.	Annual lease	$144,000
b.	Residual value	$122,000

Alt. 3 Long Term Lease

a.	Annual lease	$132,000

Alt. 4 Lease with Option to Purchase (option exercised at the end of 18 months).

a.	Annual lease	$156,000
b.	Purchase price	$610,000
c.	Purchase option credit of 80% of rental paid	($187,200)
d.	Annual maintenance of Government owned equipment	$ 29,700

Solution

The present value analysis for Alternatives 1 through 4 are shown in Tables 10-2 through 10-5 respectively. The results show that Alternative 2: Lease to Ownership is the least costly alternative with a discounted life-cycle cost of $586,200.

NOTE: Because there is no feasible current system the alternatives cannot be compared in differential terms as in the previous example.

TABLE 10-2
PRESENT VALUE ANALYSIS
ALTERNATIVE 1: PURCHASE
($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY0	$610.0		$610.0	1.000	$610.0	$610.0
FY1		$22.3	22.3	.954	21.3	631.3
FY2		29.7	29.7	.867	25.7	657.0
FY3		29.7	29.7	.788	23.4	680.4
FY4		29.7	29.7	.717	21.3	701.7
FY5		29.7	29.7	.652	19.4	721.1
FY6	(122.0)	29.7	(92.3)	.592	(54.6)	666.5

TABLE 10-3

PRESENT VALUE ANALYSIS

ALTERNATIVE 2: LEASE TO OWNERSHIP

($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY0				1.000		
FY1		$144.0	$144.0	.954	$137.8	$137.8
FY2		144.0	144.0	.867	124.8	262.6
FY3		144.0	144.0	.788	113.5	376.1
FY4		144.0	144.0	.717	103.2	479.3
FY5		144.0	144.0	.652	93.9	573.2
FY6	($122)	144.0	22.0	.592	13.0	586.2

TABLE 10-4

PRESENT VALUE ANALYSIS

ALTERNATIVE 3: LONG TERM LEASE

($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY0				1.000		
FY1		$132.0	$132.0	.954	$125.9	$125.9
FY2		132.0	132.0	.867	114.4	240.3
FY3		132.0	132.0	.788	104.0	344.3
FY4		132.0	132.0	.717	94.6	438.9
FY5		132.0	132.0	.652	86.1	525.0
FY6		132.0	132.0	.592	78.1	603.1

TABLE 10-5
PRESENT VALUE ANALYSIS

ALTERNATIVE 4: LEASE WITH OPTION TO PURCHASE[1]
($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY0				1.000		
FY1		$156.0	$156.0	.954	$148.8	$148.8
FY2	$422.8	92.8	515.6	.867	447.0	595.8
FY3		29.7	29.7	.788	23.4	619.2
FY4		29.7	29.7	.717	21.3	640.5
FY5		29.7	29.7	.652	19.4	659.9
FY6	(122.0)	29.7	(92.3)	.592	(54.6)	605.3

[1]Purchase option exercised after 18 months.

Example 10-4

A naval base on the east coast currently contracts all its ADP workload with a commercial timesharing company. The commander at that activity feels that current costs are too high and therefore has directed his staff to perform an economic analysis to evaluate alternate means of acquiring ADP support. An economic analysis was performed which evaluated three alternatives: commercial time sharing (current system; in-house operation and NARDAC support. The results of the analysis are shown in Tables 10-6 through 10-8. The NARDAC alternative has the lowest present value cost and therefore is the least costly alternative.

TABLE 10-6

PRESENT VALUE ANALYSIS

ALTERNATIVE: COMMERCIAL TIME SHARING

($000)

COST ELEMENT	FY1	FY2	FY3	FY4	FY5	FY6	FY7	TOTAL COST
Recurring Costs:								
RJE Equipment Rental		$ 30	$ 30	$ 30	$ 30	$ 30	$ 30	$ 180
Telecommunications		$ 35	$ 35	$ 35	$ 35	$ 35	$ 35	$ 210
Timesharing Services		$285	$285	$285	$285	$285	$285	$1710
TOTAL UNDISCOUNTED COSTS		$350	$350	$350	$350	$350	$350	$2100
DISCOUNT FACTOR	.954	.867	.788	.717	.652	.592	.538	
TOTAL DISCOUNTED COSTS		$303	$276	$251	$228	$207	$188	$1453

TABLE 10-7
PRESENT VALUE ANALYSIS

ALTERNATIVE: IN-HOUSE
($000)

COST ELEMENT	FY1	FY2	FY3	FY4	FY5	FY6	FY7	TOTAL COST
One-time Costs:								
ADPE Purchase	$570							$570
Site Prep	50							50
System Conversion	173							173
ADPE Residual Value							($57)	(57)
Recurring Costs:								
ADPE Maintenance		$36	$36	$36	$36	$36	36	204
Operating Personnel		50	50	50	50	50	50	300
TOTAL UNDISCOUNTED COSTS	$793	$86	$86	$86	$86	$86	$29	$1252
DISCOUNT FACTOR	.954	.867	.788	.717	.652	.592	.538	
TOTAL DISCOUNTED COSTS	$757	$75	$68	$62	$56	$51	$16	$1085

TABLE 10-8
PRESENT VALUE ANALYSIS

ALTERNATIVE: NARDAC
($000)

COST ELEMENT	FY1	FY2	FY3	FY4	FY5	FY6	FY7	TOTAL COST
One-time Cost								
System Conversion	$234							$234
Recurring Costs								
RJE Equipment Rental		$30	$30	$30	$30	$30	$30	180
Telecommunications		23	23	23	23	23	23	138
NARDAC Operating Cost		125	125	125	125	125	125	750
TOTAL UNDISCOUNTED COSTS	$234	$178	$178	$178	$178	$178	$178	$1302
DISCOUNT FACTOR	.954	.867	.788	.717	.652	.592	.538	
TOTAL DISCOUNTED COSTS	$223	$154	$140	$128	$116	$105	$ 96	$962

CHAPTER 11

UNIFORM ANNUAL COSTS

INTRODUCTION

So far comparisons of investment proposals have been limited to the use of the present value technique. This involves putting all costs and receipts for each alternative in terms of their worth as of the date a comparison is made. The present value technique is designed for alternatives having equal economic lives. It is not unusual, however, for service lives to differ from alternative to alternative. When this occurs, it is necessary to put all the alternatives on a common basis of time in order to make a valid comparison. A technique used to accomplish this is the Uniform Annual Cost (UAC) method.

UNIFORM ANNUAL COST

The UAC technique is a cost-oriented approach to evaluating alternatives with unequal economic lives. The technique involves putting all life-cycle costs and receipts for each alternative in terms of an average annual expenditure. The alternative with the lowest UAC is the most economical choice.

To understand the rationale behind this technique, consider the cash-flow diagrams shown in Figure 11-1.

CASHFLOW DIAGRAM · UNEQUAL ECONOMIC LIVES

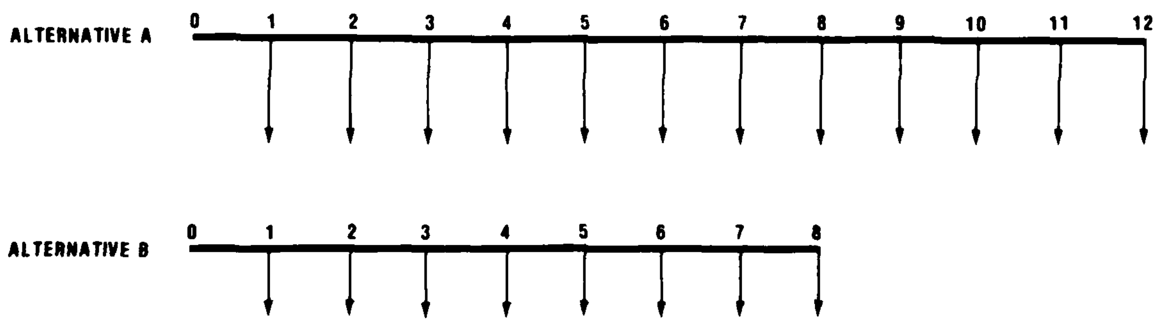


Figure 11-1

The following assumptions apply:

1. The cash-flow diagrams represent alternatives addressed to the same requirement.

2. No end is foreseen to the requirement, nor do technological considerations play any significant role. It is, therefore, the limitation of physical life which constrains the economic lives of Alternatives A and B to 12 and 8 years, respectively.

3. The only costs associated with each alternative are the uniform recurring costs shown in Figure 11-1.

4. The two alternatives provide an equivalent level of benefits per year. Thus, even if these benefits are difficult to quantify, it is clear in view of the unequal economic lives that the total benefits afforded by Alternatives A and B are not the same.

5. The annual cost of Alternative A exceeds that of Alternative B (as suggested by the cash-flow diagrams).

Which alternative is preferable? Alternative B costs less per year, but Alternative A provides benefits over a longer period of time, and the requirement is open-ended.

Actually, the choice can be simplified if one additional assumption is made:

6. Each alternative may be repeated indefinitely, with the same cash-flow pattern.

If assumption 6 is valid, Alternative A may be reinstated once and Alternative B twice to arrive at the situation depicted in Figure 11-2.

This strategy extends both alternatives to a common point in time. Because of the general assumption that the alternatives yield comparable benefits per year, the extended Alternatives A_1 and B_1 provide equivalent levels of total benefits over the common 24-year period. From Figure 11-2 it is obvious that Alternative B_1 costs less--it requires a smaller expenditure in each of the 24 years. On this basis, Alternative B is preferred.

CASH FLOW DIAGRAMS - UAC

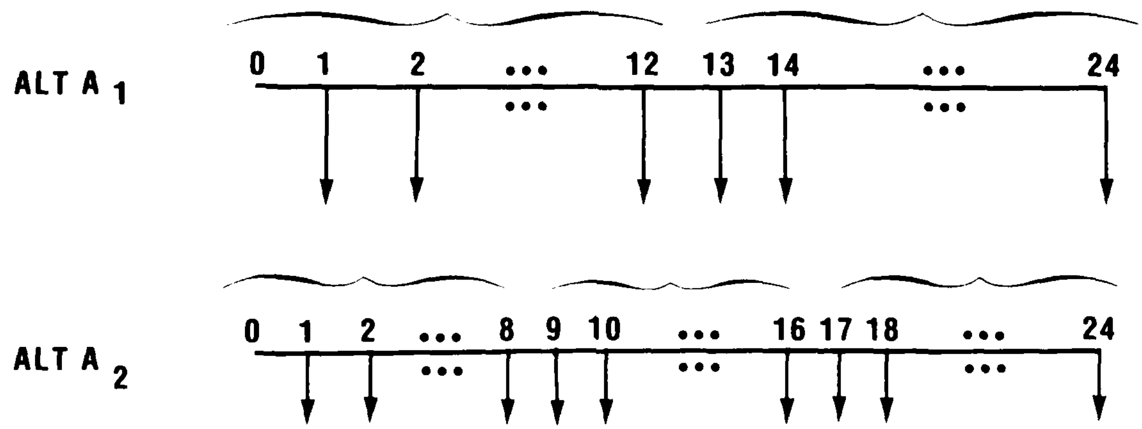


Figure 11-2

In real life one could scarcely expect cash-flow patterns to be so simplistic. More likely, there would be substantial investment cost, and perhaps other one-time costs as well. There is no guarantee that the annual recurring costs would be uniform.

A general unequal-economic-life situation might resemble that of Figure 11-3. Here the better economic choice is not obvious even if the costs and economic lives are explicitly known.

CASH FLOW DIAGRAMS
TYPICAL UNEQUAL-ECONOMIC LIFE SITUATION

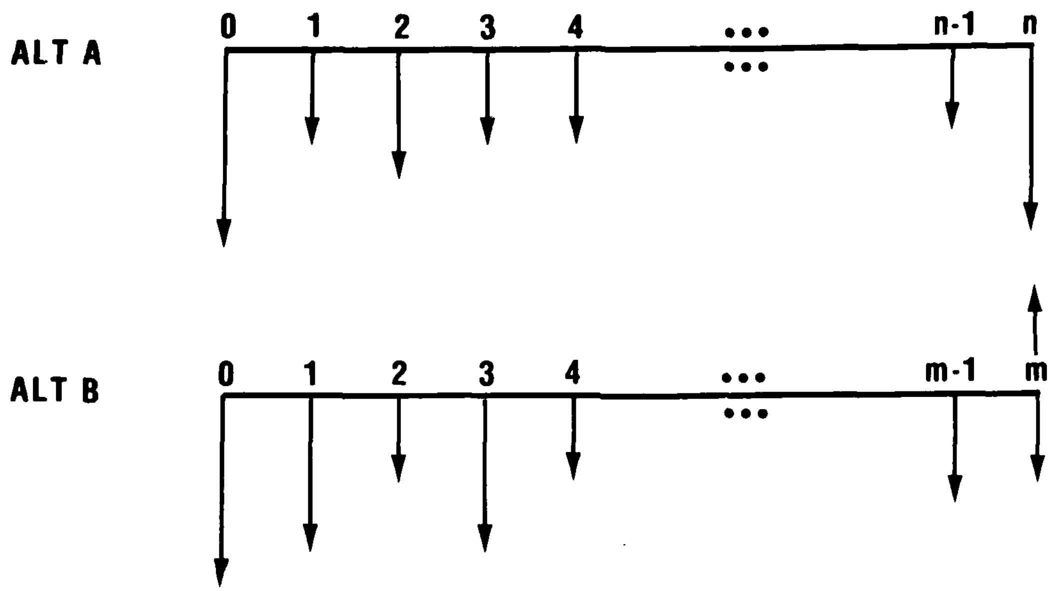


Figure 11-3

The technique of uniform annual cost consists of converting each alternative into an equivalent hypothetical alternative having uniform recurring costs such as those in Figure 11-1. The conversion is such that the total net present value costs of the actual alternative and its hypothetical equivalent are the <u>same</u>. The hypothetical alternatives may then be compared. Once the preferred hypothetical alternative is determined, the corresponding actual alternative becomes the economic choice for the project.

<u>CALCULATION OF UAC</u>

The analytical mechanism for calculating the UAC for an actual alternative is as follows:

First, determine the present value (PV) cost of the alternative. That is, find the sum of each year's discounted costs using the discount rate of 10%.

Second, divide the PV by the sum of the discount factors for the economic life of the alternative. Cumulative discount factors are found in Table B of Appendix C. The formula for determining the Uniform Annual Cost therefore becomes:

$$UAC = \frac{PV}{b_n}$$

where b_n represents the nth year Table B factor,

The UAC represents the amount of money which if budgeted in equal yearly installments would pay for the project. Note, that this is not the same as taking a simple average. For example, a theoretical building with a 25-year life and an acquisition cost of $100 million would have an average annual acquisition cost of $4 million. Using the technique of UAC, the annual cost would be approximately $10 million for the same building.

Simple Avg.	UAC
$\frac{\$100M}{25} = \$4M$	$\frac{PV}{b_n} = \frac{\$100M}{9.524} = \$10M$

The use of a simple average for determining average annual cost for economic analysis purposes is inappropriate because it fails to acknowledge the time value of money. The UAC on the other hand does incorporate this concept in its formula. In the above example the significance of the $10M uniform annual cost is this: If $10M were to be spent each year for 25 years, the total net present value of the payments would be $100M, the same as the actual net PV cost of the alternative.

The financing of a new car provides a typical example of the use of the UAC concept. When purchasing a new car on time, the finance company will use the UAC concept to arrive at the amount and number of payments necessary to reduce the balance to zero. (Since car payments are usually monthly, the payments are based on an equivalent <u>monthly</u> cost instead of equivalent annual cost.) The payments will be higher than the simple arithmetic average due to interest charges. Thus, UAC is a type of average cost that includes interest costs.

Example 11-1

New ADPE will be purchased for one of the NARDACs. Two equally effective alternatives are under consideration. The following information has been provided:

	Alternative A	Alternative B
Initial Cost ($000)	$325	$300
Yearly Operating Costs ($000)		
1	35	25
2	35	25
3	35	25
4	45	45
5	60	30
6	35	-
7	35	-
Service Life	7 yrs	5 yrs

Which is the more economical equipment to own and operate?

Solution

First it is necessary to compute the PV cost for both alternatives. The calculations are displayed below:

$$PV_A = \$325+\$35(2.609)+\$45(.717)+\$60(.652)+\$35(5.108-3.977) = \underline{\$527}$$

$$PV_B = \$300+\$25(2.609)+\$45(.717)+\$30(.652) = \underline{\$417}$$

Each PV is then divided by the cumulative present value factor corresponding to that alternative's economic life. The uniform annual cost computations for the two alternatives are as follows:

$$\text{Alternative A:} \quad UAC = \frac{PV_A}{b_7} = \frac{\$527}{5.108} = \$103$$

$$\text{Alternative B:} \quad UAC = \frac{PV_B}{b_5} = \frac{\$417}{3.977} = \$105$$

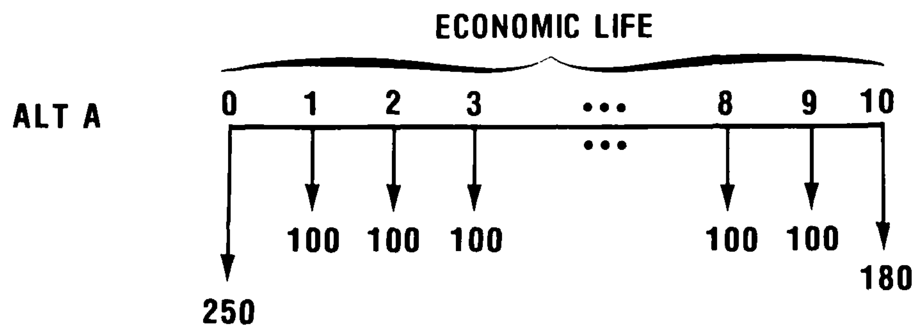
Since Alternative B has the lower uniform annual costs, it is the one to be recommended.

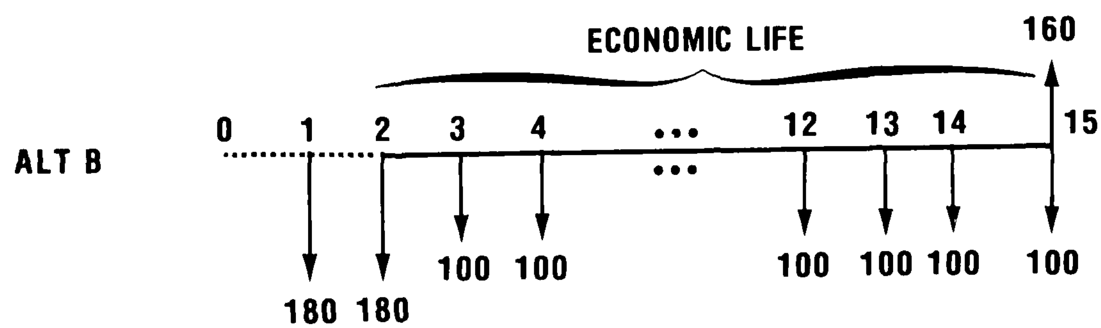
UAC AND LEADTIME

The technique of UAC should spread cash-flows over the actual economic life only, and not over any period of leadtime, even if costs are actually incurred during such a period. Consider the following example:

Example 11-2

Perform a UAC comparison on the two alternatives represented by the following cash-flow diagrams.





Alternative A, which starts offering benefits immediately, has an investment cost of $250 and an annual cost of $100. The extra one-time cost of $180 in the tenth year might be, say, for demolition, dismantling and removal of an asset.

Alternative B has a total investment cost of $360 spread uniformly over a two-year lead time. The alternative does not become operational until the beginning of year 3, at which

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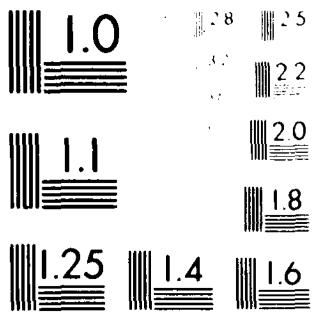

1.0
2.8
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

point its economic life starts. (The lead time period is dashed in the cash-flow diagram to indicate that it is not part of the economic life. The total 15-year period shown is referred to as the <u>project life</u> of the alternative.) This alternative, too, requires an annual expenditure of \$100. Terminal value of the asset is \$160.

<u>Solution</u>

Alternative A:

$$PV = \$250 + \$100(6.042) + \$180(0.405) = \$927$$

$$UAC = \frac{\$927}{6.447} = \$144$$

Alternative B:

$$PV = \$180(1.821) + \$100(7.980 - 1.821) - \$160(0.251) = \$904$$

$$UAC = \frac{\$904}{7.980 - 1.821} = \frac{\$904}{6.159} = \$147$$

NOTE: The economic life of Alternative B extends over a 13-year period (from the beginning of year 3 through the end of year 15). The equivalent uniform annual cost, \$147, is that amount which, if paid annually from year 3 through year 15, would total \$904 in today's dollars, the same as the PV of the actual alternative.

A generalization of the approach used in this example would be the following: If an alterative has a <u>project life</u> of n years, of which the first m years is leadtime (and therefore not part of the economic life), its uniform annual cost is given by:

$$UAC = \frac{PV}{b_n - b_m}$$

In this example, Alternative A is economically preferable because it has the lower uniform annual cost.

However, had the <u>mistake</u> been made of dividing \$904 by 7.980 (the 15-year cumulative present value factor) in the UAC computation for Alternative B, \$113 would have been obtained. Since this is less than the UAC obtained for Alternative A, Alternative B would have erroneously been concluded to be preferable.

SUMMARY

In summarizing the key ideas presented in the chapter, it should be reemphasized that Uniform Annual Cost is an economic analysis technique used to compare two or more alternatives having different lives. The technique converts a stream of expenditures over a number of years to a constant amount for each year in the time frame. Calculation of the UAC involves dividing the present value of the alternative by the cumulative discount factor associated with its economic life, thereby taking into account the time value of money. Thus, the analysis does not reflect actual cash outlays, but is only used for comparison purposes as part of the decision-making process.

CHAPTER 12

SAVINGS/INVESTMENT RATIO

INTRODUCTION

Many economic analyses evolve from a situation where a given requirement is already being met at the present time, but a less costly situation is perceived. To measure the degree of financial benefit attained from that investment one may compute a savings/investment ratio (SIR).

The SIR can be defined as the relationship between future cost savings (or avoidances) and the investment cost necessary to effect those savings. An SIR of 1 indicates that the PV of savings is equal to the PV of the investment. Thus, for an investment to be economically sound, the SIR must be greater than 1.

Notice that nowhere in the discussion have benefits been mentioned. The SIR is a characteristic of costs only and can be used to analyze individual investments or to rank competing investment projects.

COMPUTATION OF SIR

In order to understand the concept of SIR, consider the general situation depicted in Figure 12-1. Cash-flow Diagram A represents the status quo and Diagram B, the proposed alternative. Both extend over an economic life of n years.

When computing an SIR, the analyst is not interested in total operations costs--only the difference between life-cycle operating costs for the two alternatives. That is, the effect the investment has on the operation. Thus, the crucial question in Figure 12-1 is the following: Are the recurring savings of B relative to A sufficient to warrant the investment cost I that would be necessary to implement Alternative B? "Savings" means the reduced amount of annual expediture resulting from replacement of the status quo by the proposed alternative. In Figure 12-1, the total present value savings (of Alternative B relative to A) are:

$$PV(S) = PV(A_1 - B_1) + PV(A_2 - B_2) + \ldots + PV(A_n - B_n)$$

where S denotes savings and the notation PV means "present value of." The savings/investment ratio is:

$$SIR = \frac{PV(S)}{I}$$

Clearly, Alternative B should not be undertaken unless the SIR exceeds unity (i.e., unless future discounted savings more than offset the initial investment cost).

CASHFLOW DIAGRAMS - SIR EXAMPLE

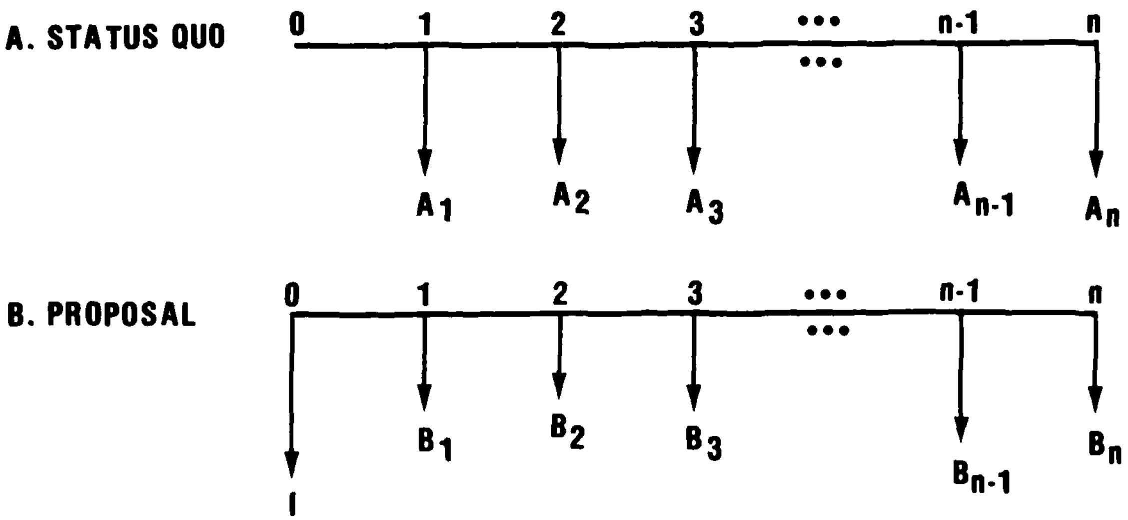


Figure 12-1

REFINEMENT OF SIR

The above equation captures the essence of the savings/investment ratio idea. A refinement to the SIR can be made by closely examining the nature and timing of the cost elements involved. For example, if the initial investment I associated with Alternative B extends over more than one year, the total present value of I should be inserted into the SIR, yielding

$$SIR = \frac{PV(S)}{PV(I)}$$

If Alternative B also includes a terminal value T, the present value of T should be netted against the investment I as follows:

$$SIR = \frac{PV(S)}{PV(I)-PV(T)}$$

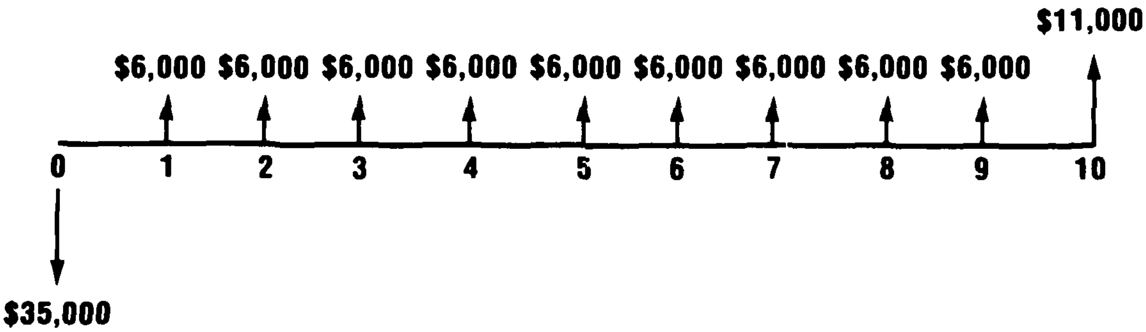
The presence of other singular cost elements, such as the value of assets replaced or a refurbishment cost to sustain the status quo, would necessitate still further refinements.

Example 12-1

Production management has proposed purchase of a numerically controlled cutting machine. The initial investment will be $35,000. It is anticipated that this machine will reduce operating costs by $6,000 per year during its 10 years of operation. Salvage value after 10 years is $5,000. Is this investment economical?

Solution

A single cash-flow diagram depicting the costs between the proposed alternative and the status quo is shown below:



The SIR can be calculated by determining the ratio of the present value of the savings to the present value of the investment less the present value of the terminal value:

$$SIR = \frac{PV(S)}{PV(I)-PV(T)}$$

$$= \frac{\$6,000(6.447)}{\$35,000-\$5,000(.405)}$$

$$= \underline{1.17}$$

Since the SIR is greater than 1.0, the investment is economically sound.

COMPARING COMPETING INVESTMENT PROJECTS

SIRs are useful because they provide the decision-maker with a means of comparing the "profitableness" of various investment projects. The SIR reflects the amount of savings that will result for each dollar invested. Thus, the greater the SIR, the more profitable the investment. For example, an investment with an SIR of 1.25 is more profitable than an investment with an SIR of 1.10 because it yields 15 cents more savings for each dollar invested.

Of course, we know that the Government is not in business to make a profit. Decisions to fund various projects are not based solely on economics. Benefits (which are not considered in the SIR) also play an important role. However, if we disregard benefits and assume that a number of investment programs are equally worthwhile, then the SIR technique would be a valid decision tool for setting priorities among investment projects.

Example 12-2

The commander at a Naval Supply Center has earmarked $1200K for new investment projects. Four projects were identified for possible funding. Each is considered to be equally worthwhile. Given the following information, determine which projects should receive funding.

Projects	Initial Investment	Annual Savings	Economic Life
Upgrade ADPE	$600K	$150K	6 yrs
Implement Inventory Accounting Systems	600K	125K	8 yrs
Mechanize Warehouses	300K	60K	10 yrs
Acquire Better Material Handling Equipment	300K	80K	6 yrs

Solution

The SIRs of each project are determined below:

Upgrade ADPE: $SIR = \frac{PV(S)}{PV(I)} = \frac{150(4.570)}{600} = \underline{1.14}$

Inventory Acct. Syst.: $SIR = \frac{PV(S)}{PV(I)} = \frac{125(5.597)}{600} = \underline{1.17}$

Mechanize Warehouses: $SIR = \frac{PV(S)}{PV(I)} = \frac{60(6.447)}{300} = \underline{1.29}$

Material Handling Equipment:

$$SIR = \frac{PV(S)}{PV(I)} = \frac{80(4.570)}{300} = \underline{1.22}$$

All four projects are cost effective since each has an SIR greater than one. However, because of the $1200K budget constraint only the projects with the greatest SIRs will be funded this year.

USING SIRS IN ECONOMIC ANALYSES

We have already shown that the SIR technique can be used to set priorities among <u>various</u> unrelated projects. When funds are limited, those projects with the highest SIRs will generally be funded. In an economic analysis, however, we are focusing on a <u>single</u> project and the alternate ways of accomplishing its objectives. While a number of alternatives are compared and ranked against each other, only one will be selected. That alternative will generally be the least costly alternative. In the economic analysis, the SIR establishes a relationship between a proposed alternative and its status quo. When there is more than one alternative, the SIR technique will determine which alternative produces the most savings per dollar invested, however, it will <u>not</u> necessarily determine the least costly alternative. Consequently, the results of the SIR technique can be misleading to the decision-maker. Therefore, it is suggested that the SIR technique be reserved for analyses which compare only one proposed alternative to the status quo. The following example demonstrates what could happen if the SIR is used to compare alternatives in an economic analysis.

Example 12-3

The operating costs at a data processing installation (DPI) have been increasing substantially each year. The increase is due primarily to the high maintenance costs on the government owned equipment and the high personnel costs associated with operating the equipment. A plan to expand the computer center and replace existing equipment has been submitted for evaluation. If the expansion takes place, the current plans to modify and refurbish the computer room 2 1/2 years from now would be eliminated. A one-year lead time is required for site preparation and system development before the system becomes operational. Given the following cost data which alternative would you choose?

ADPE Replacement

Cost Element	Status Quo	Purchase	Lease
One-time:			
ADPE Purchase	0	4000	0
Site Preparation	0	1200	1200
System Development	0	800	800
Existing ADPE Replaced	0	(1300)	(1300)
Computer Room Refurbishment	500	0	0
Terminal Value of ADPE	(130)	(400)	0
Recurring:			
ADPE Rental	0	0	1700
ADPE Maintenance	1500	1000	700
Personnel	5000	3000	3000
Economic Life	5 yrs	5 yrs	5 yrs

Solution

In order to compute the SIRs for the Purchase and Lease Alternatives, the SIR formula must be modified as follows:

$$SIR = \frac{PV(S) - PV(R)}{PV(I) - PV(T)}$$

Where: S = Savings
I = Initial investment less value of existing assets replaced.
R = Refurbishment eliminated
T = Terminal value of investment

Thus,

$$SIR\ (Purchase) = \frac{3.616(\$2500) + .788(\$500)}{.954(\$4700) - .592(\$400)} = \underline{2.22}$$

$$SIR\ (Lease) = \frac{3.616(\$1100) + .788(\$500)}{.954(\$700)} = \underline{6.55}$$

The Lease alternative has a higher SIR and appears to be less costly. However, before choosing which alternative to recommend, evaluate each using the present value techniques.

$$
\begin{aligned}
\text{PV (Status Quo)} &= .788(\$500) + 3.616(\$1500 + \$5000) \\
&\quad - .592(\$130) \\
&= \$394 + \$23,504 - \$77 \\
&= \underline{\$23,821}
\end{aligned}
$$

$$
\begin{aligned}
\text{PV (Purchase)} &= .954(\$4000 + \$1200 + \$800 - \$1300) \\
&\quad - .592(\$400) + 3.616(\$1000 + \$3000) \\
&= \$4484 - \$237 + \$14,464 \\
&= \underline{\$18,711}
\end{aligned}
$$

$$
\begin{aligned}
\text{PV (Lease)} &= .954(\$1200 + \$800 - \$1300) \\
&\quad + 3.616(\$1700 + \$700 + \$3000) \\
&= \$668 + \$19,526 \\
&= \underline{\$20,194}
\end{aligned}
$$

The results of the PV Analysis show the Purchase Alternative is really the least cost alternative.

CHAPTER 13

DISCOUNTED PAYBACK ANALYSIS

INTRODUCTION

Probably the most widely understood method for comparing alternative investments (or for evaluating a single investment) is "payback" analysis. Most simply defined, payback is the period of time required for a project's accumulated savings to offset investment costs. Thus, if one were to consider a project costing $100, yielding savings of $25 annually, its payback period would be four years.

Note that the economic connotation of payback is not affected by the duration of the project's life. (For example, a 4.5 year payback means the same thing whether the economic life is 10 years or 25 years.) The payback method is sometimes used to establish priorities for competing projects. Projects having quick payoffs are generally preferred.

DISCOUNTED PAYBACK ANALYSIS

The example described above is not a true representation of payback as used in the Navy. There are two major shortcomings.

First, the four year payback represents an undiscounted payback. By failing to recognize the timing of cash flows within a project payoff period, undiscounted payback ignores an important element, the "time value of money." For example, a project costing $350,000 that will return $50,000 per year for 10 years appears to be a good investment. The return will be $500,000. Based on the method described above the project will amortize itself in seven years. However, application of the 10% discount factor over the full 10 years yields present value savings of only $322,350. Thus, such a return would not adequately cover investment costs.

A second weakness of the example lies in its failure to address cash flows beyond a period necessary to recover initial investment costs. If significant one-time costs (e.g., major repair or overhaul costs) are to occur after the estimated point of payback, the economic attractiveness of the proposed project will be overstated.

By incorporating a "time value" element and including all future cash flows, the concept can be modified to determine the "discounted payback" pericd. Thus, payback would be achieved when accumulated present-value savings are sufficient to offset (i.e., amortize) the total present-values investment (less its terminal value) cost of a proposed alternative. The payback

period is simply the total elapsed time between the point of initial investment and the point at which payback will occur. Since savings is a necessary factor for computing payback this technique can only be used when there is a status quo[1].

Example 13-1

Preliminary studies indicate that by purchasing a new printer Navy Regional Data Automation Center (NARDAC) Pensacola can save $1,500 annually. The cost of the equipment is $5,000. During the fifth year the equipment will undergo major maintenance costing $3,000. The equipment will have an economic life of eight years and a terminal value of $500. Determine the discounted payback period for the equipment.

Solution

The present value of the equipment less its terminal value is:

$$PV(I) - PV(T) = \$5000 + .652\ (\$3000) - .489\ (\$500) = \$\underline{6712}$$

The present value of the savings can be computed as follows:

Year	Savings	10% Discount Factor	PV(S)	Cumulative PV(S)
1	$1,500	.954	$1,431	$1,431
2	1,500	.867	1,300	2,731
3	1,500	.788	1,182	3,913
4	1,500	.717	1,076	4,989
5	1,500	.652	978	5,967
6	1,500	.592	888	6,855
7	1,500	.538	807	7,662
8	1,500	.489	734	8,395

Since total life-cycle savings of $8,395 are greater than the investment cost we know that the proposed alternative is economical and should be implemented. Total investment costs will be recouped during year 6 when PV(S) = PV(I) - PV(T).

The exact point of payback can be found through interpolation. First subtract year 5 Cumulative PV(S) from the PV(I). This will give the discounted dollar value of savings occurring

---

[1] In the private sector, payback is achieved when profits offset investment. Thus, payback can be computed even when there is no status quo. However, since the Government is not in the business to make a profit, use of the payback technique is limited to situations when there is a status quo.

in year 6 which attribute to payback ($6,712 - $5,967 = $745). Next divide this amount by the total PV(S) for year 6 to find the proportion of that year during which the investment is being payed back ($745/$888 = .829). Thus, the "discounted payback" is 5.8 years.

When annual savings remain constant throughout the entire economic life, cumulative discount factors in Table B can be used to compute payback. Discounted payback for the above example would be computed as follows:

First, divide total discounted, investment cost by the annual savings:

$$\frac{PV(I) - PV(T)}{\text{Annual Savings}} = \frac{\$6712}{\$1500} = \underline{4.475}$$

Next, compare this value to the cumulative discount factors in Table B. The corresponding project year will be the point of payback. The value 4.475 falls between the discount factors for years 5 and 6. Again, by interpolating, the exact point of payback can be computed to be 5.8.

NOTE: The cumulative discount factor computed above corresponds to the period of time during which the alternative is accruing savings (i.e. its economic life). When there is lead time this value must be adjusted by adding to it the cumulative factor for the lead time period.

ADVANTAGES OF PAYBACK

The main advantage to computing the discounted payback period is that it lets the decision-maker know exactly how long it will take to recoup costs. Alternatives with short payback periods provide greater assurance that costs will indeed be recouped. For example, due to uncertainty about future conditions (i.e. war, peace, inflation, technology) the need for the system may suddenly change. A new breakthrough in technology may make a system obsolete long before payback occurs. When this happens all hopes of recouping investment costs are abandoned.

DISADVANTAGES OF PAYBACK

Payback is biased toward alternatives having low investment costs, since they can generally be payed back rather quickly.

Furthermore, the payback method provides no means of comparing lease-vs-buy alternatives, since the lease may require no initial investment cost. This of course would yield a zero payback period regardless of the length of the leasing contract.

But most importantly, payback will not necessarily identify the least costly alternative; it merely identifies the point in time when total investment costs will be recouped. Payback fails to consider those additional savings which occur beyond the payback period.

Example 13-2

Certain accounting tasks are now being performed manually. Two methods of automating these tasks are being evaluated against the present system. Life-cycle costs for the three alternatives are listed below. Initial investment costs for the proposed alternatives will be spread uniformly over a two-year lead time. The system will become fully operational in year 3. Determine the payback period for each of the proposed alternatives.

	Status Quo	Alternative 1	Alternative 2
Initial Investment	0	\$8,000	\$15,000
Annual Operating	\$12,000	\$9,000	\$ 7,000
Terminal Value	0	\$ 800	\$ 1,500
Economic Life	8 yrs	8 yrs	8 yrs

Solution

The payback periods for alternative 1 and 2 are computed as follows:

Step 1: Determine cumulative factors corresponding to economic life.

Alternative 1:

$$\frac{PV(I) - PV(T)}{\text{Annual Savings}} = \frac{1.821(\$4000) - .405(\$800)}{\$3000} = 2.320$$

Alternative 2:

$$\frac{PV(I) - PV(T)}{\text{Annual Savings}} = \frac{1.821(\$7500 - .405(\$1500)}{\$5000} = 2.610$$

Step 2: Adjust for lead time.

Alternative 1: 2.320 + 1.821 = 4.141

Alternative 2: 2.610 + 1.821 = 4.431

By comparing these values to Table B discount factors we see that discounted payback occurs in year 6 for Alternative 1 and year 6 for Alternative 2.

NOTE: However, this does not imply that Alternative 1 is the least costly alternative. The least costly alterntive is determined by computing the net present values for the alternatives as follows:

PV(Status Quo) = 4.626($12,000) = $55,512

PV(Alternative 1) = 1.821($4000) + 4.626($9000) - .405($800) = $48,594

PV(Alternative 2) = 1.821($7500) + 4.626($7000) - .405($1500) = $45,433*

*The least costly alternative is Alternative 2.

CHAPTER 14

BREAK-EVEN ANALYSIS

INTRODUCTION

Break-even analysis is an important analytical technique used to study the relationship between alternative cost patterns. Here the analysis focuses on finding the value of the variable (the "break-even point") at which the manager is indifferent regarding two possible courses of action. At the break-even point the economic desirability of the two alternatives is equal. To either side of the point one alternative or the other has the economic advantage.

BREAK-EVEN CHART

The nature of break-even analysis is depicted in Figure 14-1, a basic break-even chart. Here, the horizontal axis is scaled to measure time in yearly intervals. However, any other convenient and meaningful measurement could be used, such as the number of units produced or hours of machine operation. The vertical axis is scaled off in dollars and against the two axes are measured the discounted life-cycle cost patterns for each of the alternatives. The intersection of the two cost curves determines the break-even point. In this case it occurs during year 4. To the left of the point the cumulative cost for Alternative 1 is less than for Alternative 2. At the break-even point they are equal and to the right they are greater.

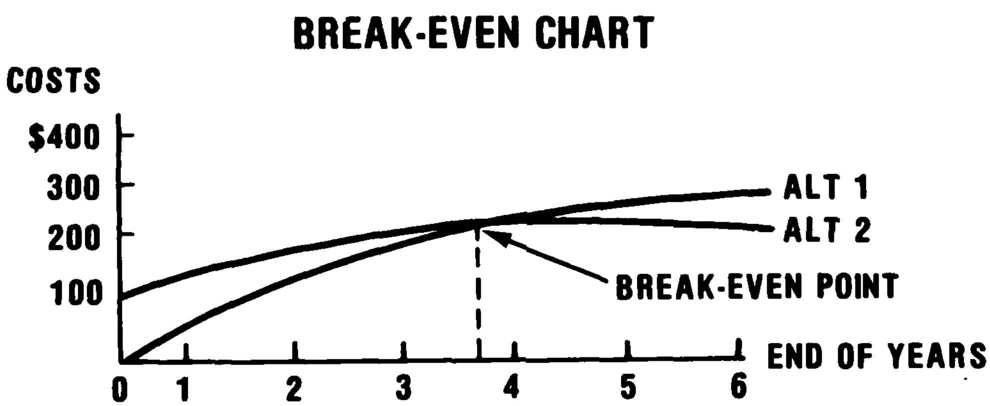


Figure 14-1

Break-even charts are useful in economic analyses because they provide the reader with the capability to visually compare the alternatives at any point in time. They are convenient, effective, readily accepted and easily understood.

BREAK-EVEN ANALYSIS AND VARIABLE OPERATING COSTS

Break-even analysis is also a useful tool for analyzing the financial characteristics of alternative operating methods when relative desirability is dependent upon some future variable (such as the number of units produced, the number of hours of machine operation, the quantity of packages handled). Here the analysis focuses on how total costs vary with output as operations become more mechanized or automated, thus, substituting fixed costs for variable costs.

The following example is a simple illustration of a break-even analysis where the time value of money is not involved.

Example 14-1

This problem involves selecting between two types of ADP printers. For each printer there is a certain cost of setting the equipment up for production. In addition there is a cost charged for each and every page produced by the equipment. Given the following cost data, determine the job size that represents the break-even point between the two alternatives:

	Printer A	Printer B
Set up costs	\$2.00	\$3.50
Unit cost per page	\$.015	\$.010

Solution

Figure 14-2 depicts the break-even analysis. The vertical axis represents dollars per job while the horizontal axis measures number of units per job. Cost lines for each machine are plotted.

The cost line for Printer A is below that for Printer B when there are fewer than three hundred pages per job. When more than three hundred pages are required Printer B is cheaper. Of course, if the job requires exactly three hundred pages then there is no difference between the two machines on the basis of costs.

BREAK - EVEN CHART - - ADP PRINTERS

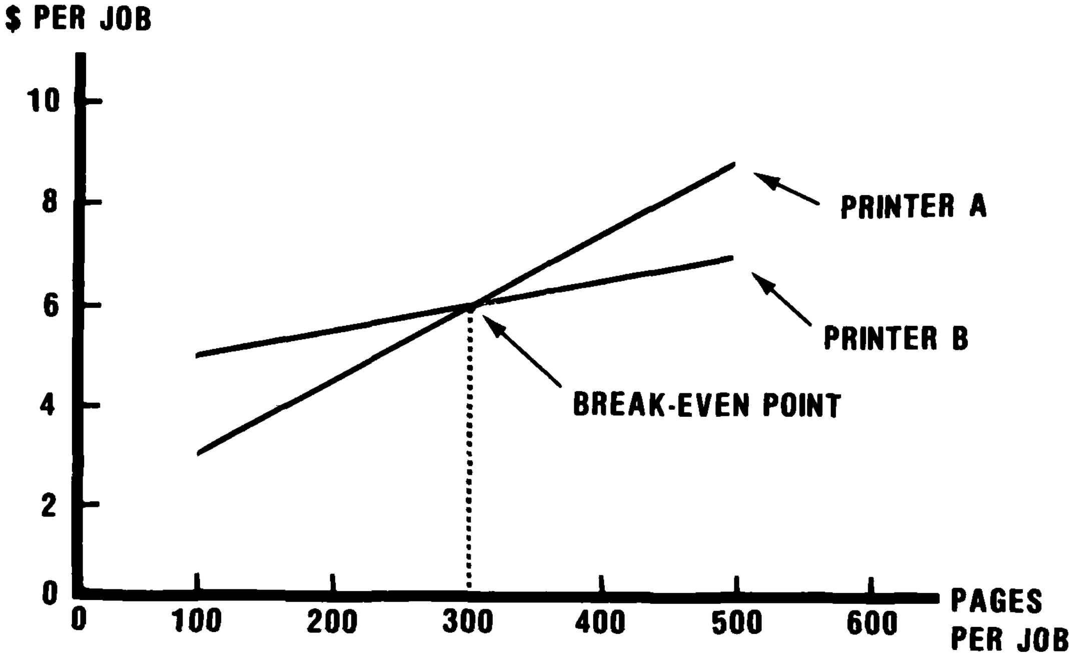


Figure 14-2

<u>ALGEBRAIC BREAK-EVEN ANALYSIS</u>

Although break-even charts provide a useful means of illustrating cost relationships, algebraic techniques are typically a more efficient means for analyzing decision problems. The algebraic technique for solving a break-even problem consists of setting the cost equations for each alternative equal and solving the unknown. The general cost equation is: TC = FC + VC(x) where:

TC = Total cost	FC = Fixed cost
VC = Variable cost	x = Unknown break-even point

The two equations for Example 14-1 become:

TC (Printer A) = \$2.00 + \$.015x
TC (Printer B) = \$3.50 + \$.010x

Setting them equal and solving for "x" gives:

$$\$2.00 + \$.015x = \$3.50 + \$.010x$$
$$\$.005x = \$1.50$$
$$x = \underline{300}$$

Thus, the break-even point is three hundred pages.

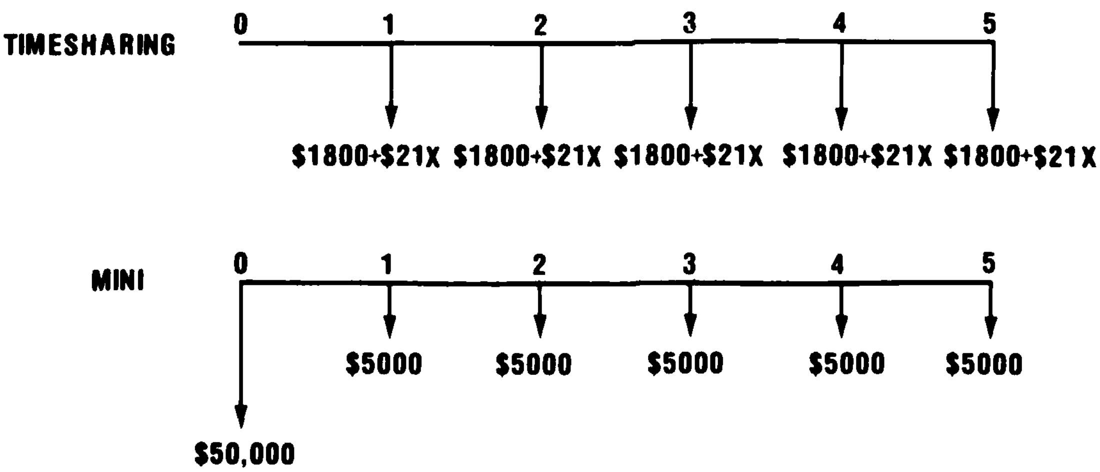
The following example incorporates the time value of money and algebraically solves for the break-even point in a problem involving variable operating costs.

Example 14-2

Currently ADP support in one economic research office is being provided through a local commercial timesharing service. The only equipment involved is a CRT which is rented for $1800 per year. Variable charges for using the service are based solely on connect time. This rate is $21 per hour. Since the size of the staff will be increasing soon, it is likely that the usage of the system will also increase. A minicomputer and all software required to make the equipment comparable to the timesharing services can be purchased for $50,000 with an annual maintenance cost of $5,000. If the life of the mini is 5 years, determine the number of hours the equipment must be used per year to make the investment worthwhile.

Solution

The choice between alternatives depends upon the number of hours per year the computer will be used by the analyst. Hours of annual usage is symbolized by the variable "x". Cash-flow diagrams are:



The present values for the two alternatives are:

$$PV\ (\text{Timesharing}) = (\$1800 + \$21x)\ 3.977$$
$$= \$7158.60 + \$83.50x$$

$$PV\ (\text{Mini}) = \$50{,}000 + \$5000\ (3.977)$$
$$= \$69{,}885$$

To determine the break-even points, set the two present values equal and solve for "x":

$$PV\ (\text{timesharing}) = PV\ (\text{Mini})$$
$$\$7158.60 + \$83.52x = \$69{,}885$$
$$\$83.52x = \$62{,}726.40$$
$$x = \underline{751}\ \text{hours}$$

Thus, use of the ADP equipment 751 hours per year will result in identical costs for both alternatives. If the equipment is used more than 751 hours per year, investment in the mini is worthwhile.

If usage is less than 751 hours commercial timesharing service is the most economical alternative.

With this information, the analyst need not have a fixed estimate of future use. He is concerned only with whether the usage will be greater than or less than 751 hours per year. Of course, if anticipated usage is a range around 751, the break-even technique has not really solved the analyst's original problem. Quite often, however, the break-even point falls outside the anticipated range and selecting an investment for recommendation has been simplified.

CHAPTER 15

BENEFIT COST RATIOS

INTRODUCTION

So far this handbook has considered techniques in which the comparison of alternatives focuses only on the costs. These techniques are useful if benefits associated with all alternatives are roughly comparable. However, there are many instances when the assumption of equivalent benefits is a poor one. Therefore, some technique must be devised for comparing alternatives which assesses both costs and benefits. The technique generally recommended is the Benefit Cost Ratio (BCR) technique.

BENEFIT COST RATIO

One of the first things to consider when evaluating a possible investment is whether or not it will yield benefits commensurate with the costs. The economic desirability of an investment can be determined by calculating BCR by simply dividing the benefits by the costs. This gives the manager a single number or value for the investment. This value represents the amount of benefits obtained per unit of cost.

Separate BCRs are computed for each alternative. The alternative with the highest BCR is the most cost effective (i.e., it returns the most benefits for each dollar spent).

The method of computing the BCR will vary from analysis to analysis depending upon the number of benefits involved and whether or not the benefits are quantifiable.

In all cases, since costs are spread over a designated period of time, the time value of money must be incorporated in the calculation.

BCR AND QUANTIFIABLE BENEFITS

Many projects have a stated goal defined in terms of required output (e.g., to reduce errors; to decrease response time; to process an increased workload, etc). The goal is not always quantified, but it often is susceptible to quantification and thus provides a potential measure of benefits associated with the project.

When output can be quantified, the appropriate formula for the BCR is:

$$BCR = \frac{\text{Quantifiable Output Measure}}{\text{Uniform Annual Cost}}$$

In this expression, the UAC is calculated as described in Chapter 11. The UAC is used in the calculation because it accounts for both the time value of money and the fact that alternatives will often have different economic lives. The quantifiable output measure is merely a quantified statement of expected output over some designated period of time for the alternative under investigation. No significance should be attached to the fact that a computed BCR may be less than unity. This is due entirely to the dimensional quality of the BCR and the arbitrarily chosen baseline (for example, cards punched per minute vs. cards punched per hour). The only valid comparison is <u>between</u> the two ratio measures. Their relationships to unity has no significance whatsoever. (The reader should not confuse this situation with that of the savings investment ratio, in which the significance of unity is crucial.)

Some examples of quantifiable output measures follow:

- Number of pages printed per hour
- Number of reports generated per week
- Number of work orders processed per month
- Number of transactions recorded per minute
- Decreased error rate per job

This list is by no means exhaustive, but it should provide the analyst with a good perception of what a measure is, and should assist him in formulating specific measures tailored to his particular analytical problem. Note, that savings have already been accounted for in the cost analysis and, therefore, cannot be used again as an output measure.

When using this technique, the analyst should use the most significant output factor to compute the BCR. When there are several significant factors the analyst may elect to compute BCRs for each.

The following example illustrates the BCR technique when output is quantifiable.

<u>Example 15-1</u>

Government contractors are reviewed periodically to assure that they are complying with federally established equal opportunity standards. Currently a manual process is being used to collect, analyze and maintain this data. Each contractor should be reviewed annually. However, because the manual process is slow and tedious, only 23% of the workload is accomplished (i.e., 39,000 reviews per year). A proposed automated information system could double the number of reviews performed by reducing much of the manual effort dedicated to scheduling reviews and generating follow-up reports. Costs for the two alternatives are:

	Manual	Automated
One-time (yr 1)		$2,175,000
Recurring (yrs 2-9)	$1,650,000	$2,050,000

Using the annual number of reviews as a measure of benefits, determine the BCR for each alternative.

Solution

The BCRs for the manual and automated systems are computed using the following formula:

$$BCR = \frac{\text{Quantifiable Output Measure}}{\text{Uniform Annual Cost}}$$

The quantifiable output measures for the automated and manual systems are 78,000 and 39,000, respectively.

Using the formula developed in Chapter 11, the uniform annual cost for each system is computed as follows:

$$UAC = \frac{PV}{b_n - b_m}$$

$$\text{UAC (Automated)} = \frac{\$2,175,000(.954) + \$2,050,000(6.042 - .954)}{6.042 - .954}$$

$$= \frac{\$2,074,950 + \$10,430,400}{5.088}$$

$$= \$2,457,812$$

$$\text{UAC (Manual)} = \frac{\$1,650,000(6.042 - .954)}{6.042 - .954}$$

$$= \frac{\$8,395,200}{5.088}$$

$$= \$1,650,000$$

By substituting the quantifiable output measures and the Uniform Annual Costs into the Benefit Cost Ratio formula we get:

$$\text{BCR (Automated)} = \frac{78,000}{\$2,457,812} = \underline{.03}$$

$$\text{BCR (Manual)} = \frac{39,000}{\$1,650,000} = \underline{.02}$$

The proposed automated system has a higher BCR than the current manual system. Therefore it is the more cost-effective alternative.

BCR AND NONQUANTIFIABLE BENEFITS

The BCR technique can still be used even when precise quantification of benefits is impossible. The analyst may arbitrarily assign an aggregate benefit value to each alternative. Because this method of evaluating benefits is so subjective the analyst must be sure to include his rationale for deriving the aggregate benefit values.

One possible approach for developing an aggregate benefit value is illustrated in Table 15-1. The "in house" and the "contract-out" alternatives are ranked on each of four decision factors. The factors themselves have been assigned weights to establish their relative importance to one another. The ranking is done on a scale of 0 to 10 inclusive, where 0 means "of no value" and 10 represents an "attainable ideal." In this example a system which rates ideal on all four factors would have an overall rating of $3 \cdot 10 + 2 \cdot 10 + 2 \cdot 10 + 3 \cdot 10 = 100$, where we have multiplied the ranking of each factor by the factor weight and summed the results. Based on the actual rankings in Table 15-1, the same calculation yields a result of 82 for the in house alternative and 79 for the contract out alternative.

TABLE 15-1

BENEFIT RANKINGS

Decision Factor	Factor Weight	In House	Contract Out
Data availability	3	9	7
Data timeliness	2	8	10
Data accuracy	2	6	7
Utility for decision-making	3	9	8

Once aggregate benefit values are established BCRs can be computed for each alternative using the following formula:

$$BCR = \frac{\text{Aggregate Benefit Value}}{\text{Uniform Annual Cost}}$$

In this example, if the UAC for the in house and contract out alternatives are \$120K and \$100K, respectively, the benefit cost ratios are computed as follows:

$$\text{BCR In House} = \frac{82}{\$120K} = \underline{.68}$$

$$\text{BCR Contract-out} = \frac{79}{\$100K} = \underline{.79}$$

Thus, the contract out alternative yields a higher return per dollar spent.

Part V

Sensitivity Analysis

CHAPTER 16

UNCERTAINTY

INTRODUCTION

Depending upon the amount of information or the number of facts available, the analyst will find himself in one of two environments: "certainty" or "uncertainty." Under certainty, all facts, actions and results are known. Under uncertainty, not all facts are available. The analyst must make various assumptions in order to create an environment which can be assessed. When uncertainties exist in an analysis, each must be carefully examined to determine its effect and influence on the ultimate analysis recommendation.

CERTAINTY

The ideal environment for decision-making is one in which all things are known: There is no doubt, no uncertainty. The decision-maker knows exactly what is going to happen, when it will happen, and all other related aspects. The formulation of assumptions (step 2 in the economic analysis process) is totally unnecessary because the manager is knowledgeable of everything. Obviously this type of environment is seldom (if ever) encountered.

UNCERTAINTY

The estimates of costs and gains considered so far are average, predicted or "expected" outcomes. But, we know that for all sorts of reasons these amounts may be off the mark. The actual costs of development or production never precisely coincide with advance estimates. This is not because the analyst is lazy or careless in his estimation. Rather it is because of the inherent uncertainty which surrounds both the current and future environment. The most common types of uncertainty are:

Uncertainty about planning and cost factors. Every model uses as inputs certain relations between its elements which are known as "planning factors," (e.g., the time it takes to perform a certain function, the number of people required to accomplish a given workload, the amount of CPU time required to run a particular program). Planning factors are the main ingredient in estimating costs. Because this information cannot always be predicted with complete accuracy uncertainty will exist in the analysis.

Requirements Uncertainty. Requirements uncertainty has to do with variations stemming from changes in the configuration of the system being analysed. When a new system is conceived its preliminary design seldom turns out to be exactly the same as the final design. Changes will take place in the requirements and the characteristics which comprise the system. Requirements can change for political, technological, environmental and economical reasons. Estimates for systems' costs have historically relied upon the preliminary design information. If the preliminary characteristics of the system are in error, then early cost estimates relying upon those characteristics will likewise be in error.

Technological Uncertainty. Technological uncertainty deals with the likelihood that the desired output cannot be achieved. Technological uncertainty is rarely a serious problem in analyses of current operational problems, but as we try to peer further and further into the future it becomes more and more important and can indeed dominate the analysis. Technological uncertainty is the central problem in research and development decisions.

Statistical Uncertainty. Finally, there is "statistical" uncertainty, the uncertainty resulting from the chance element in recurring events. This is the kind of uncertainty that would persist even if we could predict the central values of all important parameters. We know that if we flip a penny a thousand times, it will come down "heads" approximately half of the time; but if we flip it only ten times, the proportion of heads may be much higher or lower. In most long-range problems, statistical uncertainties are the least of our worries.

TREATMENT OF UNCERTAINTY

Now that we know that uncertainty does exist in economic analyses, what do we do about it? The most important advice is: Don't ignore it. To base an analysis and decision on some single set of best guesses could be disasterous. For example, suppose that there is uncertainty about ten factors and we make a best guess on all ten. If the probablity that each best guess is 60 percent, the probability that all ten are right is about one-half of one percent. If we confined the analysis to this best-guess case, we would be ignoring a set of futures with a 99.5 percent probability of occurring. Because uncertainties can have a significant impact on the results, we must design the analysis to reflect all major uncertainties. This usually means computing results for a number of contingencies. The number of cases to analyze and compute increases with each additional factor. Therefore the problem is to design the analysis to reflect only the most significant contingencies. A number of techniques can be used when dealing with uncertainty. Several are discussed below.

Simulation. One technique designed to assist managers in making decisions under uncertainty is computer simulation. Assuming that the probability distributions can be assigned to each of the major cost determinents, a computer program can be constructed to simulate what is likely to occur. In effect, the computer selects one value at random from each of the relevant distributions, combines it with other values selected from other distributions, and produces an estimated value for the investment. This process is repeated for a number of trials. When the computer runs are completed the frequency with which the various values occurred can be plotted as a frequency distribution. While simulation can prove to be very useful, the technique does require obtaining probability distributions for a number of variables and involves a fair amount of programming and machine time costs. Full scale simulation therefore is generally feasible only for large and expensive projects.

Sensitivity analysis. A somewhat less expensive simulation technique is available as an alternative method of analyzing the outcomes of various projects or strategies. Instead of using probability distributions for each of the variables in the problem, we can simulate the results by starting with the best-guess-estimate for each variable, then changing the values of the variables (within reasonable limits) to see the effects of changes. This technique, known as sensitivity analysis, is considerably less expensive than the full-scale simulation and provides data for decision-making purposes.

Contingency analysis. Contingency analysis is a form of sensitivity analysis and involves evaluating the effect of new factors or conditions. The analyst reflects these new aspects by asking himself questions of the type "what happens if...?" For instance, after a comparison of two computer systems results in an established preference, the decision-maker might ask "What happens if a new computer family is developed in 5 years?" Or he might ask, "What happens if our department is closed? Can the system be adapted to another operation?" The chance that these "what ifs" might occur can be quite subjective or might possibly have probability assigned.

A Fortiori Analysis. This technique is used generally in attempting to overcome preconceived bias of the decision-maker when comparing alternatives. A not uncommon situation involves replacement of a current, satisfactory production machine with new equipment. The responsible official is usually quite hesitant to make the change since there is an element of uncertainity--the unknown performance of the new machine. Considering this uncertainty and the fact that the new machine is not essential (the old one is performing satisfactorily),

the decision-maker is likely to dismiss the change with only perfunctory consideration--thus precluding possible superior performance. "A fortiori" analysis is also rather perfunctory, resulting not in firm recommendations, but only in indications. Its use is dependent upon the decision-maker's realization of his inner bias. With this realization, the decision-maker sets the numerical values of any unknown in favor of the less desired alternative. That is, he counteracts his bias for one alternative by favoring the other. In our example, the official would set minimum values for operating cost and maintenance downtime and a maximum value for production output of the new equipment. If, in this case, the eventual comparison of alternatives is favorable for the "old machine", the decision-maker is assured that his inner bias did not force the decision. However, if the comparison favors the new machine, a more complete evaluation is necessary in order to determine more realistic values of the variables.

CHAPTER 17

SENSITIVITY ANALYSIS

INTRODUCTION

Once all costs and benefits have been measured and a preference ranking of alternatives has been established, the analyst will find that his task is still incomplete. Due to uncertainties in the analysis the decision maker will want to know not only the economic choice implied by the "best estimate" of input variables but also whether or not that decision would change if one or more of the inputs would vary. It is the role of sensitivity analysis, the last of the six basic steps of the economic analysis process, to provide this information.

SENSITIVITY ANALYSIS

Sensitivity refers to the relative magnitude of change in one or more elements of an economic analysis that will cause a change in the ranking of alternatives. In a sensitivity analysis if one particular factor or cost element can be varied over a wide range without affecting the ranking of alternatives, the analysis is said to be insensitive to uncertainties regarding that particular element.

Contingency analysis is a special form of sensitivity analysis which permits the analyst to consider the potential impact of major changes in the real world on the alternatives. Contingency analysis answers the "what if" questions concerning the economic analysis (e.g., What if the economic life were 5 years instead of 8? What if demand increases by 50%?)

Sensitivity/contingency analysis does not require any sophisticated techniques. What is required is the ability to recognize uncertainties in the economic analysis and to deal with them in a logical manner.

STEPS IN PERFORMING A SENSITIVITY ANALYSIS

First, the analyst must determine whether or not a sensitivity analysis is really necessary in the economic analysis. If there is complete certainty and the preference ranking of alternatives establishes one option as markedly superior to the rest, the analyst should not be overly concerned about testing for sensitivity. It is only when there is uncertainty and the economic choice is not clear cut that further investigation is required.

If a sensitivity analysis is indicated, the analyst must then select which parameters to test. There is no single aspect or criterion which can be presented that will provide a sure-kill approach to selecting the most important parameter or factor in all sensitivity analyses. Each analysis is

unique in that it possesses its own set of costs and assumptions. As a rule, sensitivity analysis should treat dominant input variables; that is, those having a significant impact on the total present value cost and/or the benefits accruing to a given alternative. Of course, identification of the major cost contributors does not necessarily mean that the truly critical items have been isolated. The choice of input variables for sensitivity may depend not only upon relative dominance but also upon the degree of confidence which can be placed in these estimates. Some of the elements which should be scrutinized and evaluated are:

1. Cost Estimates. Effects of increasing or decreasing major cost elements; that is, those which have a significant impact on the present value cost.

2. Length of System Life. Effects of a shorter or longer system life.

3. Volume, Mix or Pattern of Workload. Effects of variation in the estimated volume, mix or pattern of workload.

4. Requirements. Effects of potential changes in requirements resulting from either legislative mandate or changes in functional or organizational structure.

5. Configuration of Equipment or Software. Effects of changes in configuration of hardware, software, data communications and other facilities.

6. Assumptions. Effects of alternative assumptions concerning requirements, operations, facilities and software, etc.

The basic procedure for sensitivity testing is fairly simple. Select the factor to be tested. Hold all parameters in the analysis constant except that factor. Then rework the analysis using different estimates for the factor under consideration. Check the results. If the ranking of alternatives is affected, then the analysis is sensitive to that amount change in that variable.

Each key parameter should be tested individually to determine its effect on the analysis.

Example 17-1

a. Given the following cost data, determine the less costly alternative:

	Alternative A (Proposed)	Alternative B (Status Quo)
Year One:		
ADPE	$ 80	0
System Development	100	0
Site Preparation	35	0
Years Two - Nine		
Personnel	$ 80/yr	$120/yr
Other Operating Costs	20/yr	25/yr

b. Will the results change if the system development costs are $120? $130?

c. What will be the impact if personnel costs are increased to $85 per year?

Solution

a. The net present values for Alternatives A and B are:

PV(Alt. A) = .954($80 + $100 + $35) + 5.088($80 + $20)
= $205 + $509
= $714

PV(Alt. B) = 5.088($120 + $25)
= $738

Thus, Alternative A, the proposed system is less costly.

b. If system development is $120:

PV(Alt. A) = .954($80 + $120 + $35) + 5.088($80 + $20)
= $224 + $509
= $733

Since $733 is less than the cost of the status quo alternative the analysis is not sensitive to a $20 increase in system development costs.

If the system development is $130:

PV(Alt. A) = .954 + ($80 + $130 + $35) + 5.088($80 + $20)
= $234 + $509
= $743

In this case costs would be greater for the proposed system, therefore, the analysis is sensitive to an increase of $30 in system development.

c. If annual personnel costs are increased to \$85, then:

$$\begin{aligned} PV(\text{Alt. A}) &= .954(\$80 + \$100 + \$35) + 5.088(\$85 + \$20) \\ &= \$205 + \$534 \\ &= \$739 \end{aligned}$$

Thus, the analysis <u>is</u> sensitive to this change.

<u>Example 17-2</u>

The economic life in the above example is somewhat questionable. Perform a contingency analysis to determine what would happen if the economic life was 5 years instead of 8.

<u>Solution</u>

Based on a 5 year economic life, the present values of Alternatives A and B are:

$$PV(\text{Alt. A}) = .954(\$215) + 3.616(\$100) = \underline{\$567}$$

$$PV(\text{Alt. B}) = 3.616(\$145) = \underline{\$524}$$

Alternative B is now less costly than alternative A. Since the ranking of alternatives has changed, the analysis is sensitive to the shorter economic life.

<u>SENSITIVITY AND BREAK-EVEN ANALYSIS</u>

Break-even analysis is useful for determining the point at which a particular factor becomes sensitive. In Example 17-1 a break-even point can be found for each parameter by setting the cost equations for the two alternatives equal to eacn other and solving for the unknown variable. The unknown variable in each case is the factor being tested for sensitivity. The break-even points are computed below.

System development break-even cost:

$$\begin{aligned} .945(\$80 + x + \$35) + 5.088(\$100) &= \$5.088(\$120 + \$25) \\ .954x + \$110 + \$509 &= \$738 \\ .954x &= \$119 \\ x &= \underline{\$125} \end{aligned}$$

Thus, if the system development cost is \$125 (and all other costs are held constant at their original estimates) the alternatives will have equal present values. If the system development cost is less than \$125, the proposed alternative is preferred. If it is greater than \$125 the current system is preferred.

Personnel break-even cost:

$$
\begin{aligned}
.945(\$215) + 5.088(x + 20) &= 5.088(\$145) \\
\$205 + 5.088x + \$102 &= \$738 \\
5.088\,x &= \$431 \\
x &= \underline{\$84.7}
\end{aligned}
$$

PRESENTING THE RESULTS

Tables, charts and graphs can be used to highlight the results of the sensitivity analysis. Graphs are particularly useful because they provide a visual interpretation of the results over a continuous range of possibilities.

Figure 17-1 depicts the sensitivity of the system development costs. The vertical axis represents the PV cost and the horizontal axis represents the system development cost. PV costs for each alternative are graphed. The status quo remains constant at \$738. Points A, B and C represent the present values for the proposed alternative when the system development costs are \$100, \$120 and \$130, respectively. The point at which the two alternatives intercept is the break-even point. To the left of the break-even point the proposed system is cheaper and to the right the status quo is cheaper.

SYSTEM DEVELOPMENT SENSITIVITY TEST

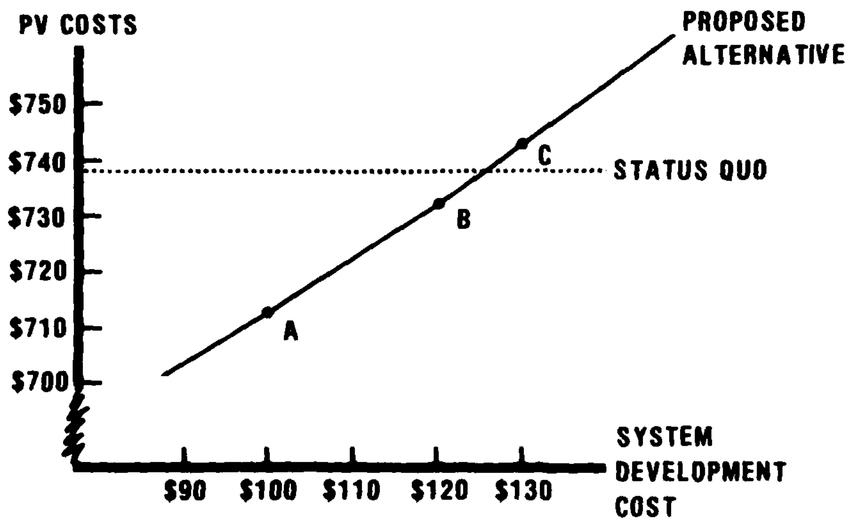


Figure 17-1

Similarly Figure 17-2 plots the sensitivity of the annual personnel costs, where points A1 and B1 represent the present values when personnel costs are \$80 and \$85, respectively.

PERSONNEL COSTS SENSITIVITY TEST

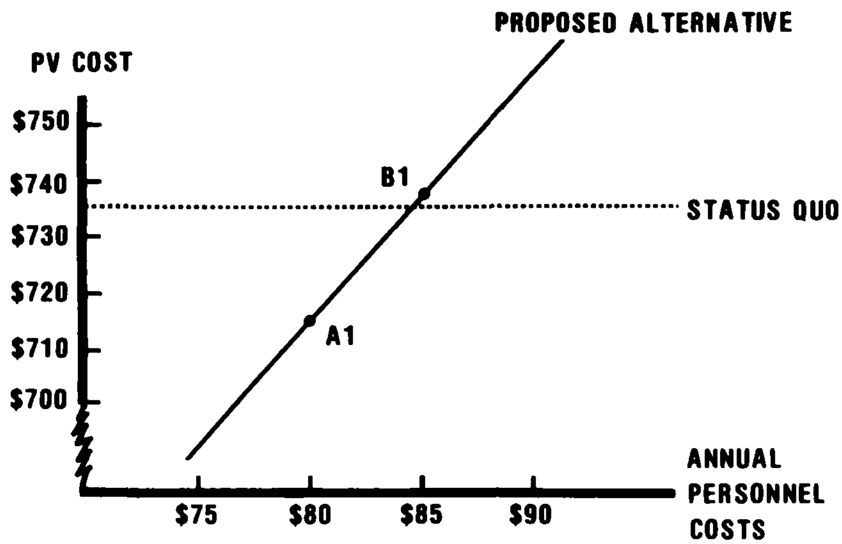


Figure 17-2

TWO VARIABLE SENSITIVITY TESTS

The outcome of an economic analysis is frequently sensitive to more than one input or assumption. The graphical techniques developed in the previous section may be extended to treat the two variables simultaneously. For example, the PV life-cycle cost of the proposed alternative in Example 17-1 can be depicted for simultaneous variations in annual personnel costs and system development costs. If the system development cost is denoted; by D and the annual personnel cost by P, total PV life-cycle cost is:

$$PV = .954(80 + D + 35) + 5.088(P + 20)$$

Figure 17-3 shows plots of total PV life-cycle costs for various combinations of system development and personnel costs. The personnel cost, P, is plotted on the horizontal axis and the development cost, D, is treated as an exogenous variable. The lattice of PV life-cycle cost points readily indicates which combinations of system development and personnel costs are economically preferable to the status quo. The circled point represents the "best guesses." (D = \$100, P = \$80) used in the original analysis.

Inspection of the graph reveals whether or not the proposed alternative is economically justified -- it is if, and only if, the PV point for the proposed alternative lies below the status quo threshold. The graph also allows the reader to visually interpolate between designated development and personnel costs. For example, if the actual system development cost were $110 and the annual personnel cost were $77 the PV would be approximately $708 (see point Y in Figure 17-3).

TWO VARIABLE SENSITIVITY ANALYSIS

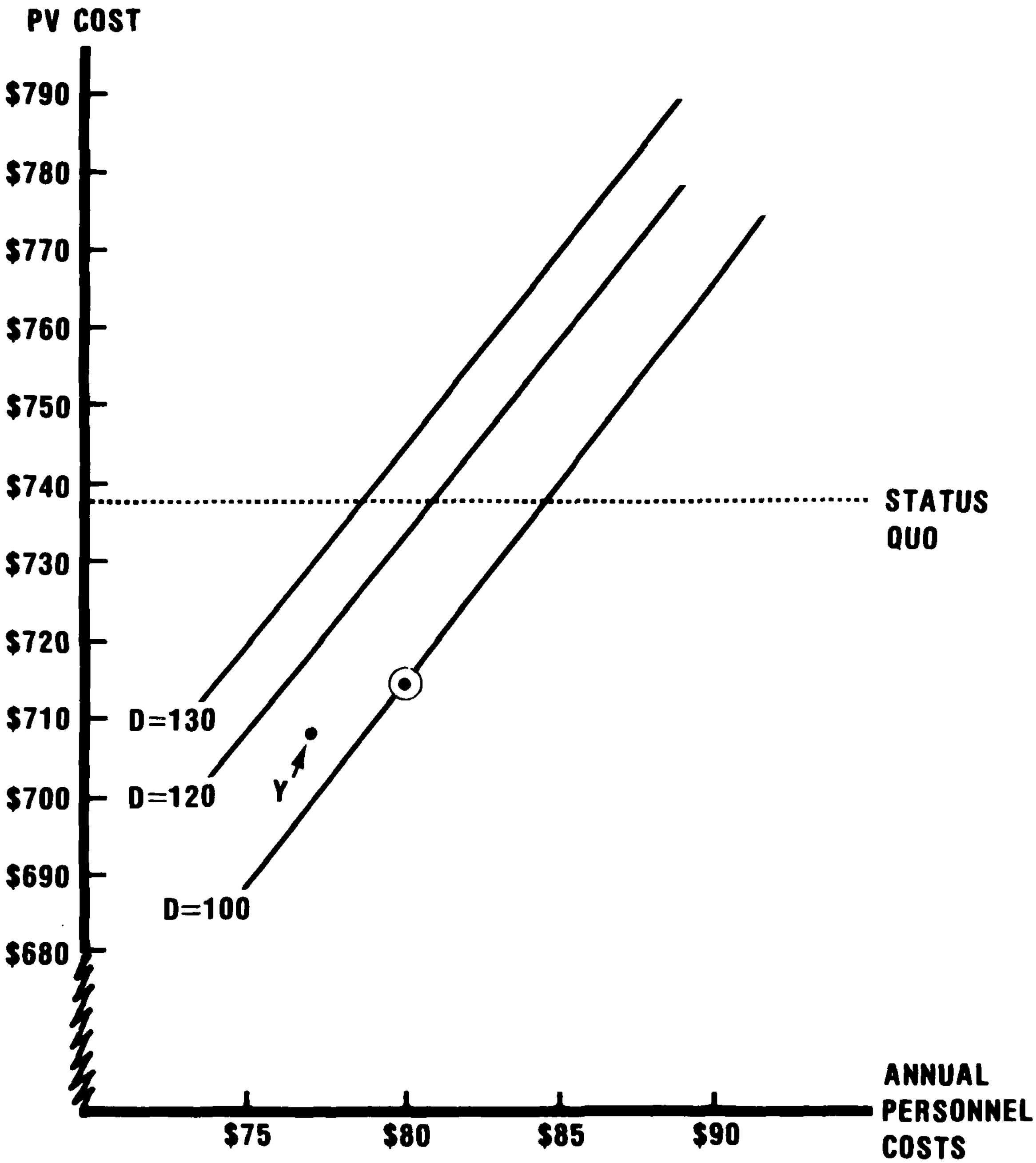


Figure 17-3

Appendix A

Writing the Economic Analysis Report

Appendix A

WRITING THE ECONOMIC ANALYSIS REPORT

WRITING THE REPORT

The economic analysis report is the major tangible product of the study; it is the most important tool for management in deciding whether to implement the study recommendatins. As such, it must be a product of good quality, written and presented with the same care that was exercised in the other phases of the study.

The findings and recommendations of the study must be presented to several levels of management within the organization. For this reason, the report should be written with varying amounts of detail in the various parts of the report, as described below.

Executive Summary. This is a concise summary of the economic analysis findings. It is placed at the beginning of the report to inform top level management of the coverage of the study, specifically the major costs and benefits and the study recommendations. This part of the report is particularly important because top management generally does not have time to devote to report details. Therefore, the summary must be succinct and at the same time, must present the salient findings of the study.

Main Body of the Report. The part of the report which is detailed should discuss all relevant findings, recommendations, benefits and special observations or considerations and if applicable, should include suggested steps for implementation.

Appendexes. Use appendexes at the end of the report to present lengthy, detailed data to support the report findings and recommendations.

VISUAL AIDS FOR PRESENTING DATA

Whenever possible, visual aids should be used to display data. Visual presentations such as charts, graphs and figures improve the report's readability by helping the readers to comprehend the impact of the ratios and relationships being discussed. Charts, graphs and figures included in the report should be clear, brief, and specifically related to points being discussed in the text.

SUGGESTED OUTLINE FOR THE REPORT

While there is no set format for preparing the economic analysis report a suggested outline is provided below:

I. INTRODUCTION

A. Background. Provide the reader with a general overview of the existing environment. Identify the specific problem or opportunity being studied and provide an historical account of major events leading to the problem.

B. Scope. Identify the scope of the study.

C. Methodology. Summarize the procedures for conducting the economic analysis and the techniques used in estimating and computing costs and benefits. The techniques may be detailed in an appendix.

II. OBJECTIVE

State the major objective(s) of the program/project under study. Objectives should be stated in terms of a functional need without implying how they are to be accomplished.

III. ASSUMPTIONS

State all assumptions under which the economic analysis was based. Include the expected economic life and the period to be used in the comparison. Also include any constraints, limitations, or exclusions related to the analysis.

IV. ALTERNATIVES

Describe the technical and operational characteristics of the alternatives considered, including the existing system.

A. Current System. The current system represents the alternative which seeks to identify the level of costs and benefits which would accrue without changing the present method of operation. If a current system exists and is considered feasible it will serve as a baseline with which to compare new possibilities.

B. Proposed System. Describe the overall concept for each of the proposed alternatives. Alternatives which can be shown to be infeasible need not later be quantified but should be addressed.

V. COST ANALYSIS

Identify and describe cost elements for each alternative. Include the computations used to devise total costs and describe in detail the method for developing cost estimates. Use tables, charts, graphs, mathematical models and other visual aids to assist in presentation of costs.

VI. BENEFIT ANALYSIS

Identify and describe all benefits which could be attained by implementing each alternative. Quantify benefits whenever possible. Identify criteria used for measuring benefits and include computations when applicable. Provide a general narrative description of all intangible benefits. Do not include savings under benefits. They have already been considered in the cost analysis section.

VII. COMPARISON OF ALTERNATIVES

Compare alternatives using an appropriate economic analysis technique. Present results in a convenient fashion using charts, tables, graphs or other visual aids whenever possible. NOTE: Whenever the period of comparison is greater than three years the alternatives must be compared in terms of discounted costs and benefits.

VIII. SENSITIVITY ANALYSIS

Describe the approach and assumptions used for conducting the sensitivity analysis. Identify and display the results of analysis for all alternatives for each factor tested. Use tables, graphs and charts for presenting data, include a narrative to highlight key points in the evaluation.

IX. CONCLUSIONS

Present the conclusion in a clear, concise manner. The conclusion should be brief statements of the most important findings presented in the report. No new material is introduced at this stage. Justifying sentences do not belong in the conclusion. The body of the report has done that already. Just make your point and stop.

Once you arrive at your conclusions, always check to make certain that your discussion substantiates them.

X. RECOMMENDATIONS

The recommendations follow from the conclusions. Recommended actions should be drafted in brief, clear, positive statements. The recommendation must meet the test of suitabilty, feasibility, and acceptability if they are to provide a complete and workable solution to the problem.

Appendix B

Economic Analysis Review Checklist

APPENDIX B

ECONOMIC ANALYSIS REVIEW CHECKLIST

THE OBJECTIVE

1. Is the objective clearly stated? Does it define the purpose of the program/project or activity under study?

2. Is the objective realistic and attainable?

3. Is the objective stated in terms of output or accomplishment?

4. Are the output/accomplishments defined in quantifiable, measurable terms?

5. Are the criteria specified for selection of a preferred course of action?

6. Can progress toward attainment of the objective be measured?

7. Is the objective statement phrased so that the type and variety of potential alternatives are not unnecessarily limited?

8. If a completion or implementation date is required, has it been specified?

THE ASSUMPTIONS/CONSTRAINTS

1. Are all reasonable assumptions identified and explained?

2. Are assumptions too restrictive? Too broad?

3. Are the assumptions realistic and justified?

4. Does each assumption have an identified basis?

5. Are assumptions used only when facts cannot be obtained?

6. Do the assumptions preclude potential alternative solutions?

7. Do assumptions include economic life and future workload?

8. Is a project time frame established?

9. Are funding/budget constraints considered?

10. Are space and construction needs included?

11. Are necessary geographical constraints included?

THE ALTERNATIVES

1. Are the alternatives feasible: Can they meet the stated objectives?

2. Are the alternatives well defined and discreet? Do they overlap?

3. Is the total number of alternatives sufficient? Have any feasible alternatives been omitted?

4. If adequate, is the "status quo" used as a base for comparison?

5. If appropriate, is lease vs. buy evaluated?

6. Have all feasible alternatives been considered?

7. Have non-analyzed alternatives been identified with reasons for omission?

8. If other government organizations can provide the desired product or service, have they been included as alternatives?

THE COST ESTIMATE

1. Are all relevant costs included?

2. Do implementation costs include shipping, installation, support and training requirements?

3. Do labor costs consider specific skill levels, fringe benefits, overtime and shift differentials?

4. Is future equipment replacement included as an investment cost?

5. Are current asset values of reutilized equipment considered (is the method of determining these values adequate)?

6. Are cost factors current and supportable?

7. Does the study indicate why certain costs are considered relevant and others not?

8. Are cost estimates properly classified and of proper quality for the status of the program?

9. Are estimating relationships and methodologies identified and adequate?

10. Are sunk costs excluded?

11. Have opportunity costs been considered?

12. Is terminal value associated with any of the alternatives?

13. Are future costs evaluated in terms of constant dollars?

14. If inflation or cost escalation is included, has the rate and the source of the rate been identified?

15. Are cost savings or avoidances determined only by comparing with the "status quo?"

16. Are the costs of any one alternative part of the analysis of only that alternative (not also as a cost savings in the evaluation of another alternative)?

17. Have cash flows been discounted at an appropriate discount rate?

THE BENEFITS

1. Have all relevant benefits been determined? Does the analysis ignore any portion of total output?

2. Do the benefits relate to the project objective?

3. Are the benefits identified in quantifiable, measurable terms as much as possible?

4. Were the criteria used to measure benefits justified by the context of the study?

5. Are estimating techniques defined?

6. Are information/estimation sources identified?

7. Was an expert opinion used? Were the experts properly qualified?

8. Where quantitative measures of benefits are missing are there logical, convincing quantitative assessments?

9. Has the analysis gone too far in attempting to quantify the unquantifiable?

10. Have negative aspects been identified and quantified?

11. Have cost reductions (i.e., savings) been excluded from the benefit list to avoid double counting?

12. Has a ranking or priority system been developed for evaluating the importance of the benefits?

13. Has all benefit information been tabulated for ease of examination?

COMPARISON OF ALTERNATIVES

1. Were alternatives compared using the proper technique(s) (e.g., present value, benefit/cost rates, break-even analysis)?

2. Are the alternatives compared in relation to a common basis?

3. Does the analysis seem free of bias in favor of a particular alternative? Was their comparison fair?

4. Were the criteria, costing methods and time span the same for all alternatives?

5. Have cost and benefit information for each alternative been combined to show relationships?

6. Were the methods and sources of comparison adequately documented?

SENSITIVITY ANALYSIS

1. Are there important underlying uncertainties in the analysis?

2. Is there important technological uncertainty?

3. Were ranges of values used for unknown quantities?

4. Is the effect of various future states of nature shown?

5. Is break-even analysis used to assist evaluation of future uncertainties?

6. Would the recommendation stay the same if an unknown characteristic varied within a feasible range?

7. Has the impact of the length of time for formal project approval been illustrated?

8. Is the analysis too optismistic in its assumptions?

9. Is there a sensitivity analysis to show the effect of uncertainty in major cost estimates?

CONCLUSIONS AND RECOMMENDATIONS

1. Are the results of the analysis conclusive? Can a concrete ranking of alternatives be established?

2. Has a specific course of action been recommended?

3. Are the conclusions and recommendations logically derived from the material?

4. Have all significant differences between the recommended alternative and others been emphasized?

5. Are the recommendations feasible in the real world of political, cultural, or policy considerations?

6. Are the recommendations based upon significant differences between the alternatives?

7. Are recommendations intuitively satisfying and supportable?

Appendix C

Project Year Discount Factors

APPENDIX C
TABLE C-1

PROJECT YEAR DISCOUNT FACTORS

Project Year	Table A PRESENT VALUE OF $1 (Single Amount-used when cash flows accrue in varying amounts each year) 10%	Table B PRESENT VALUE OF $1 (Cumulative Uniform Series-to be used when cash flows accrue in the same amount each year) 10%
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980
16	0.228	8.209
17	0.208	8.416
18	0.189	8.605
19	0.172	8.777
20	0.156	8.933
21	0.142	9.074
22	0.129	9.203
23	0.117	9.320
24	0.107	9.427
25	0.097	9.524
26	0.088	9.612
27	0.080	9.692
28	0.073	9.765
29	0.066	9.831
30	0.060	9.891

NOTE: Table B factors represent the cumulative sum of Table A factors through any given project year.

Appendix B
Inflation—Discount Factors

APPENDIX D

INFLATION-DISCOUNT FACTORS

TABLE D-1

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -5%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.933	0.933
2	0.812	1.745
3	0.706	2.450
4	0.614	3.064
5	0.534	3.598
6	0.464	4.062
7	0.403	4.465
8	0.351	4.816
9	0.305	5.121
10	0.265	5.386
11	0.231	5.617
12	0.201	5.818
13	0.174	5.992
14	0.152	6.144
15	0.132	6.276
16	0.115	6.390
17	0.100	6.490
18	0.087	6.577
19	0.075	6.652
20	0.066	6.718
21	0.057	6.775
22	0.050	6.824
23	0.043	6.868
24	0.037	6.905
25	0.033	6.938
26	0.028	6.966
27	0.025	6.991
28	0.021	7.012
29	0.019	7.031
30	0.016	7.047

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 5% slower than general price levels.

TABLE D-2

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -4%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.937	0.937
2	0.822	1.759
3	0.721	2.481
4	0.633	3.113
5	0.555	3.668
6	0.487	4.155
7	0.427	4.582
8	0.374	4.956
9	0.329	5.285
10	0.288	5.573
11	0.253	5.826
12	0.222	6.048
13	0.195	6.242
14	0.171	6.413
15	0.150	6.563
16	0.131	6.694
17	0.115	6.809
18	0.101	6.910
19	0.089	6.999
20	0.078	7.077
21	0.068	7.145
22	0.060	7.205
23	0.052	7.257
24	0.046	7.303
25	0.040	7.344
26	0.035	7.379
27	0.031	7.410
28	0.027	7.437
29	0.024	7.461
30	0.021	7.482

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 4% slower than general price levels.

TABLE D-3

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -3%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.941	0.941
2	0.833	1.774
3	0.737	2.511
4	0.652	3.164
5	0.577	3.741
6	0.511	4.252
7	0.452	4.704
8	0.400	5.104
9	0.354	5.458
10	0.313	5.772
11	0.277	6.049
12	0.245	6.294
13	0.217	6.512
14	0.192	6.704
15	0.170	6.874
16	0.151	7.024
17	0.133	7.158
18	0.118	7.275
19	0.104	7.380
20	0.092	7.472
21	0.082	7.554
22	0.073	7.626
23	0.064	7.690
24	0.057	7.747
25	0.050	7.797
26	0.044	7.841
27	0.039	7.880
28	0.035	7.915
29	0.031	7.946
30	0.027	7.973

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 3% slower than general price levels.

TABLE D-4

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -2%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.945	0.945
2	0.844	1.790
3	0.754	2.543
4	0.673	3.216
5	0.601	3.817
6	0.536	4.353
7	0.479	4.832
8	0.428	5.260
9	0.382	5.642
10	0.341	5.983
11	0.304	6.287
12	0.272	6.559
13	0.243	6.802
14	0.217	7.018
15	0.193	7.212
16	0.173	7.385
17	0.154	7.539
18	0.137	7.676
19	0.123	7.799
20	0.110	7.909
21	0.098	8.007
22	0.088	8.095
23	0.078	8.173
24	0.070	8.243
25	0.062	8.305
26	0.056	8.360
27	0.050	8.410
28	0.044	8.454
29	0.040	8.494
30	0.035	8.529

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 2% slower than general price levels.

TABLE D-5

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = -1%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.950	0.950
2	0.855	1.805
3	0.771	2.576
4	0.694	3.270
5	0.626	3.896
6	0.564	4.459
7	0.508	4.967
8	0.457	5.424
9	0.412	5.836
10	0.371	6.207
11	0.334	6.542
12	0.301	6.843
13	0.271	7.115
14	0.245	7.359
15	0.220	7.579
16	0.198	7.778
17	0.179	7.957
18	0.161	8.118
19	0.145	8.263
20	0.131	8.394
21	0.118	8.511
22	0.106	8.618
23	0.096	8.713
24	0.086	8.799
25	0.078	8.877
26	0.070	8.947
27	0.063	9.010
28	0.057	9.066
29	0.051	9.118
30	0.046	9.164

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 1% slower than general price levels.

TABLE D-6

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 0%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.954	0.954
2	0.867	1.821
3	0.788	2.609
4	0.717	3.326
5	0.652	3.977
6	0.592	4.570
7	0.538	5.108
8	0.489	5.597
9	0.445	6.042
10	0.405	6.447
11	0.368	6.815
12	0.334	7.149
13	0.304	7.453
14	0.276	7.729
15	0.251	7.980
16	0.228	8.209
17	0.208	8.416
18	0.189	8.605
19	0.172	8.777
20	0.156	8.933
21	0.142	9.074
22	0.129	9.203
23	0.117	9.320
24	0.107	9.427
25	0.097	9.524
26	0.088	9.612
27	0.080	9.692
28	0.073	9.765
29	0.066	9.831
30	0.060	9.891

*These factors are to be applied to cost elements which are anticipated to escalate at the same rate as the general price level. (This table coincides with Tables A and B, Appendix C.)

TABLE D-7

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 1%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.959	0.959
2	0.880	1.839
3	0.808	2.647
4	0.742	3.389
5	0.681	4.070
6	0.626	4.695
7	0.574	5.270
8	0.527	5.797
9	0.484	6.281
10	0.445	6.726
11	0.408	7.134
12	0.375	7.509
13	0.344	7.853
14	0.316	8.169
15	0.290	8.459
16	0.266	8.726
17	0.245	8.970
18	0.225	9.195
19	0.206	9.401
20	0.189	9.590
21	0.174	9.764
22	0.160	9.924
23	0.147	10.070
24	0.135	10.205
25	0.124	10.328
26	0.113	10.442
27	0.104	10.546
28	0.096	10.642
29	0.088	10.730
30	0.081	10.810

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 1% faster than general price levels.

TABLE D-8

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 2%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.963	0.963
2	0.893	1.856
3	0.828	2.684
4	0.768	3.452
5	0.712	4.165
6	0.660	4.825
7	0.612	5.437
8	0.568	6.005
9	0.526	6.531
10	0.488	7.020
11	0.453	7.472
12	0.420	7.892
13	0.389	8.281
14	0.361	8.642
15	0.335	8.977
16	0.310	9.287
17	0.288	9.575
18	0.267	9.842
19	0.247	10.089
20	0.229	10.319
21	0.213	10.531
22	0.197	10.729
23	0.183	10.911
24	0.170	11.081
25	0.157	11.238
26	0.146	11.384
27	0.135	11.519
28	0.125	11.645
29	0.116	11.761
30	0.108	11.869

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 2% faster than general price levels.

TABLE D-9

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 3%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.968	0.968
2	0.906	1.874
3	0.849	2.723
4	0.795	3.517
5	0.744	4.261
6	0.697	4.958
7	0.652	5.610
8	0.611	6.221
9	0.572	6.793
10	0.536	7.329
11	0.501	7.830
12	0.470	8.300
13	0.440	8.739
14	0.412	9.151
15	0.386	9.536
16	0.361	9.897
17	0.338	10.235
18	0.316	10.552
19	0.296	10.848
20	0.277	11.126
21	0.260	11.386
22	0.243	11.629
23	0.228	11.857
24	0.213	12.070
25	0.200	12.270
26	0.187	12.457
27	0.175	12.632
28	0.164	12.796
29	0.154	12.950
30	0.144	13.093

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 3% faster than general price levels.

TABLE D-10

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 4%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.972	0.972
2	0.919	1.892
3	0.869	2.761
4	0.822	3.583
5	0.777	4.360
6	0.735	5.095
7	0.695	5.789
8	0.657	6.446
9	0.621	7.067
10	0.587	7.654
11	0.555	8.209
12	0.525	8.734
13	0.496	9.230
14	0.469	9.699
15	0.443	10.142
16	0.419	10.561
17	0.396	10.958
18	0.375	11.333
19	0.354	11.687
20	0.335	12.022
21	0.317	12.339
22	0.299	12.638
23	0.283	12.921
24	0.268	13.189
25	0.253	13.442
26	0.239	13.681
27	0.226	13.908
28	0.214	14.121
29	0.202	14.324
30	0.191	14.515

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 4% faster than general price levels.

TABLE D-11

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 5%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.977	0.977
2	0.933	1.910
3	0.890	2.800
4	0.850	3.650
5	0.811	4.461
6	0.774	5.235
7	0.739	5.974
8	0.706	6.680
9	0.673	7.353
10	0.643	7.996
11	0.614	8.610
12	0.586	9.196
13	0.559	9.755
14	0.534	10.288
15	0.509	10.798
16	0.486	11.284
17	0.464	11.748
18	0.443	12.191
19	0.423	12.614
20	0.404	13.018
21	0.385	13.403
22	0.368	13.771
23	0.351	14.122
24	0.335	14.458
25	0.320	14.777
26	0.305	15.083
27	0.292	15.374
28	0.278	15.653
29	0.266	15.918
30	0.254	16.172

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 5% faster than general price levels.

TABLE D-12

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 6%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.982	0.982
2	0.946	1.928
3	0.912	2.839
4	0.878	3.718
5	0.847	4.564
6	0.816	5.380
7	0.786	6.166
8	0.757	6.923
9	0.730	7.653
10	0.703	8.357
11	0.678	9.035
12	0.653	9.688
13	0.629	10.317
14	0.607	10.924
15	0.584	11.508
16	0.563	12.071
17	0.543	12.614
18	0.523	13.137
19	0.504	13.641
20	0.486	14.127
21	0.468	14.595
22	0.451	15.046
23	0.435	15.480
24	0.419	15.899
25	0.404	16.303
26	0.389	16.692
27	0.375	17.066
28	0.361	17.427
29	0.348	17.775
30	0.335	18.111

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 6% faster than general price levels.

TABLE D-13

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 7%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.986	0.986
2	0.959	1.946
3	0.933	2.879
4	0.908	3.787
5	0.883	4.670
6	0.859	5.529
7	0.836	6.364
8	0.813	7.177
9	0.791	7.968
10	0.769	8.737
11	0.748	9.485
12	0.728	10.212
13	0.708	10.920
14	0.688	11.608
15	0.670	12.278
16	0.651	12.930
17	0.634	13.563
18	0.616	14.180
19	0.600	14.779
20	0.583	15.363
21	0.567	15.930
22	0.552	16.482
23	0.537	17.019
24	0.522	17.541
25	0.508	18.049
26	0.494	18.543
27	0.481	19.023
28	0.467	19.491
29	0.455	19.946
30	0.442	20.388

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 7% faster than general price levels.

TABLE D-14

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 8%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.991	0.991
2	0.973	1.964
3	0.955	2.919
4	0.938	3.857
5	0.921	4.777
6	0.904	5.681
7	0.888	6.569
8	0.871	7.440
9	0.856	8.296
10	0.840	9.136
11	0.825	9.961
12	0.810	10.770
13	0.795	11.565
14	0.781	12.346
15	0.766	13.112
16	0.752	13.865
17	0.739	14.603
18	0.725	15.329
19	0.712	16.041
20	0.699	16.740
21	0.687	17.427
22	0.674	18.101
23	0.662	18.762
24	0.650	19.412
25	0.638	20.050
26	0.626	20.676
27	0.615	21.291
28	0.604	21.895
29	0.593	22.488
30	0.582	23.070

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 8% faster than general price levels.

TABLE D-15

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 9%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	0.995	0.995
2	0.986	1.982
3	0.977	2.959
4	0.969	3.928
5	0.960	4.887
6	0.951	5.839
7	0.942	6.781
8	0.934	7.715
9	0.925	8.640
10	0.917	9.557
11	0.909	10.465
12	0.900	11.366
13	0.892	12.258
14	0.884	13.142
15	0.876	14.018
16	0.868	14.886
17	0.860	15.746
18	0.852	16.598
19	0.845	17.443
20	0.837	18.279
21	0.829	19.109
22	0.822	19.930
23	0.814	20.745
24	0.807	21.551
25	0.800	22.351
26	0.792	23.143
27	0.785	23.928
28	0.778	24.706
29	0.771	25.477
30	0.764	26.241

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 9% faster than general price levels.

TABLE D-16

PROJECT YEAR INFLATION-DISCOUNT FACTORS

Differential Inflation Rate = 10%*
Discount Rate = 10%

Project Year	Single Amount	Cumulative Uniform Series
1	1.000	1.000
2	1.000	2.000
3	1.000	3.000
4	1.000	4.000
5	1.000	5.000
6	1.000	6.000
7	1.000	7.000
8	1.000	8.000
9	1.000	9.000
10	1.000	10.000
11	1.000	11.000
12	1.000	12.000
13	1.000	13.000
14	1.000	14.000
15	1.000	15.000
16	1.000	16.000
17	1.000	17.000
18	1.000	18.000
19	1.000	19.000
20	1.000	20.000
21	1.000	21.000
22	1.000	22.000
23	1.000	23.000
24	1.000	24.000
25	1.000	25.000
26	1.000	26.000
27	1.000	27.000
28	1.000	28.000
29	1.000	29.000
30	1.000	30.000

*These factors are to be applied to cost elements which are anticipated to escalate at a rate 10% faster than general price levels.

Appendix E
Glossary of Terms

APPENDIX E

GLOSSARY OF TERMS

A Fortiori Analysis - A technique used to overcome a decision-maker's preconceived bias. Numerical values of unknowns are set in favor of the less desired alternative. If the eventual comparison of alternatives still favors the "preferred" alternative the decision-maker is assured that his inner bias did not force the decision.

Alternatives - The different courses of action, means, or methods by which objectives may be obtained.

Assets - Property, both real and personal, and other items having monetary value.

Assumptions - Explicit statements used to describe the present and future environment upon which the economic analysis is based. Assumptions are made to support and reasonably limit the scope of the study.

Baseline Date - The starting point for the economic analysis, beyond which decisions deal with future courses of action. It is the "today" in the analysis. May be referred to as the baseline year (or analysis year 0).

Benefits - Outputs or effectiveness expected to be received or achieved over time as a result of undertaking a proposed investment.

Benefit/Cost Ratio - An economic indicator of efficiency, computed by dividing benefits by costs. When benefits are quantified in dollar terms, it is customary to discount both the benefit stream and the cost stream to reflect the present value of future costs and benefits.

Break-Even Analysis - A procedure for evaluating alternatives in terms of a common unknown variable. It involves solving for the value of the variable which will make the cumulative discounted costs for the alternatives equivalent; this value is the break-even point.

Budget Estimate - Cost estimate prepared for inclusion in the DOD budget to support a system acquisition program.

Cash-Flow Diagrams - A pictorial representation showing the magnitudes and timing of costs associated with an alternative.

Compound Interest - Interest which is computed on both the original principal and its accrued interest.

Constant Dollars - Computed values which remove the effect of price changes over time. An estimate is said to be in constant dollars if costs for all work are adjusted so that they reflect the level of prices of a base year.

Contingency Analysis - A form of sensitivity analysis used to evaluate the effect of new factors or conditions in an analysis by asking "what if" questions.

Cost - The value of things used up or expended in producing a good or service. Costs are usually expressed in dollar terms. In economic analyses a cost value need not coincide with the budget estimate.

Cost Avoidance - Savings realized by obviating a planned nonrecurring expenditure of resources. A cost avoidance can only occur when adopting a nonstatus quo alternative.

Cost Benefit Analysis - A technique for assessing the range of costs and benefits associated with a given option, usually to determine feasibility. Costs are generally in monetary terms, but benefits need not be in monetary terms.

Cost Estimate - Cost projection for expected transaction based upon information available.

Curent Dollars - Level of costs in the year actual cost will be incurred. When prior costs are stated in current dollars, the figures given are the actual amounts paid out. When future costs are stated in current dollars, the figures given are the actual amounts expected to be paid including any amount due to future price changes.

Current Market Value - The amount for which an item could be sold in today's market. This can be the "going price" for a particular piece of used hardware in the open market or the trade-in allowance guaranteed by a particular manufacturer. Demand is greatest for computers that were at one time the most popular models--because there is a larger more receptive market. Obscure machines, on the other hand, have substantially lower prices by proportion, even though they are just as good or even better than the popular models.

Delphi Method - Technique for applying the informed judgement of a group of experts, using a carefully planned program of sequential individual interrogations, without direct confrontation; and with maximum use of feedback of digested information in the investigation and solution of problems. Usually consists of a series of repeated interrogations by means of

questionaires. After the initial interrogation of each individual, each subsequent interrogation is supplemented by information from the preceeding round of replies. The expert is encouraged to reconsider and, as appropriate, change or defend the previous reply in light of the replies of the other members of the group.

Discount Factor - The multiplier for any specific discount rate which translates expected cost or benefit in any specific future year into its present value. Mathematically the discount factor is $1/(1+r)^t$ where r is the discount rate and t is the number of years since the date of the initiation, renewal or expansion of a program or project.

Discount Rate - A rate used to relate present and future dollars. This rate is expressed as a percentage and is used to reduce the value of future dollars in relation to present dollars to account for the time value of money.

Discounted Payback - A technique for determining the time period over which accumulated present value savings are sufficient to offset the total present value investment costs of a proposed alternative to the status quo.

Discounting - A computational technique using interest rate to calculate present value of future benefits and costs. Used in evaluating alternative investment proposals that can be valued in money.

Economic Analysis - A systematic approach to quantifying, portraying, and evaluating the relative worth of proposed projects. Basically, it consists of six steps: stating the objective; listing assumptions; defining the alternatives; determining costs and benefits; comparing and ranking alternatives; and performing a sensitivity analysis.

Economic Forecasting - Predicting the future movement of economic indicators (i.e., GNP, indices, etc).

Economic Life - The period of time over which the benefits to be gained from a proposal may be reasonably expected to accrue. The economic life of a project begins the year the investment starts producing benefits and may be limited by its mission life, physical life, or technological life.

Effectiveness - The rate at which progress toward attainment of the goal or objective of a program is achieved. Rate at which the benefits of a program are produced.

Efficiency - The degree to which outputs are optimized and pertains to both the productivity and the input mix.

Fixed Cost - That component of production cost which does not change in the short run if production volume is within a specified range.

Fringe Benefits - Allowances and services provided to employees as compensation in addition to basic salaries and wages.

Historical Cost - The cost of any objective, based upon actual asset outlay, determined after the fact. Any method of cost determination may be used.

Inputed Cost - A cost that does not appear in accounting records and does not entail dollar outlays.

Incremental Cost - The additional resources needed to acquire some specific additional capability. Any cost which would be incurred regardless of which alternative is adopted is not an incremental cost and need not be included in an analysis.

Industrial Engineering Method - Cost estimating technique whereby estimates for various separate work segments are consolidated into a total project estimate.

Inflation - A persistent rise in the general level of prices over time.

Intangible Benefits - Those improvements in system performance which cannot be quantified in terms of dollars or other measures.

Interest - A price (or rent) charged for the use of money.

Investment Cost - One-time costs associated with acquisition of real property, nonrecurring services, nonrecurring operations, and maintenance (start-up) costs and other onetime costs. Despite their one-time nature, investment costs may extend over periods of more than one year.

Lead Time - The period of elapsed time between initial funding or decision and the commencement of the economic life.

Life-Cycle - The time from the beginning date of the project to the end of the program/project life.

Life-Cycle Cost - The total cost to the Government of acquisition and ownership of a system over its full life. It includes the cost of development, acquisition, operation, support, and where applicable, disposal.

Mission Life - The period of time over which a need for an asset is anticipated.

Net Discounted Cost - Discounted dollar cost minus discounted dollar benefits. (This can be a negative value.)

Nonrecurring Cost - Cost which occurs on a one-time basis; to be distinguished from annually recurring cost.

Objectives - Goals or results that the decision-maker wants to attain. It is the desired end product, or output, of a program. The objectives justify the existence of the organization and its consumption of resources. Objectives must be stated in a manner which does not preclude alternative approaches.

Opportunity Cost - The cost of forgone opportunities; the sacrificed amount of money, equipment, or units of production that could have been realized by a separate course of action (alternative) with the same time and effort expended.

Output - The products, functions, tasks, services, or capabilities which an orgaization exists to produce, accomplish, attain or maintain.

Output Measures - Useful descriptors of functions, tasks or missions performed by an organization, expressed in relation to those assigned.

Parametric Cost Estimate - Estimate derived from statistical correlation of historic system costs with performance and physical attributes of the system.

Physical Life - The estimated number of years that a machine, piece of equipment or building can physically be used in accomplishing the function for which it was procured or constructed.

Present Value - The estimated current worth of future benefits or costs derived by discounting the future values, using an appropriate discount rate.

Price Index - A percentage comparison of the total costs of a selection of commodities and services between two periods of time.

Program/Project - A major mission-oriented, agency endeavor, which fulfills statutory or executive requirements, and which is defined in terms of the principal actions required to achieve a significant end objective.

Program Evaluation - Analysis of ongoing activities to determine how best to improve an approved program/project based on actual performance. Program evaluation studies entail a comparison of actual performance with the approved program/project goals and objectives, and provide a basis for deciding whether objectives are being accomplished in the most cost-effective manner.

Project Life - The leadtime together with the economic life.

Recurring Costs - Expenses for personnel, material consumed in use, operating, overhead, support services, and other items which recur annually in execution of a given program or work effort.

Residual Value - The computed value of an asset at any point in time.

Savings/Investment Ratio (SIR) - The ratio of discounted future cost savings to the discounted investment cost necessary to effect those savings. An SIR of 1 indicates that the present value of savings is equal to the present value of the investment.

Sensitivity Analysis - A technique for assessing the extent to which reasonable changes in assumptions or input variables will affect the preference ranking of alternatives.

Simulation - Artificial generation of experimental processes to initiate or duplicate actual operational processes.

Sunk Cost - A nonrecoverable resource that has been consumed as a result of a prior decision. Because sunk costs have been irrevocably expended or committed, they play no role in a choice between alternatives.

Tangible Benefits - Those improvements in system performance which can be quantified. They do not include savings in recurring operating expenses; these savings are already reflected as reductions in cost.

Technological Life - The estimated number of years before technology will make the existing or proposed equipment or facilities obsolete.

Terminal Value - The proceeds (less removal and disposal costs, if any) realized upon disposition of a tangible capital asset. It is usually measured by the net proceeds from the sale or other disposition of the asset, or its fair market value if the asset is traded for another asset.

Time Value of Money - A name given to the notion that the use of money costs money. A dollar today is worth more than a dollar tomorrow because of the interest costs related to expenditures and benefits which occur over time. Annual savings or cash inflows projected for tomorrow have present values less than their undiscounted dollar values.

Uniform Annual Cost - A constant amount which, if paid annually throughout the economic life of a proposed alternative, would yield a total discounted cost equal to the actual present value life cycle cost of the alternative.

Variable Cost - A cost that varies with the quantity of output produced.

Appendix F

Economic Analysis Example:

Economic Analysis of the Replacement of ADPE

APPENDIX F

ECONOMIC ANALYSIS EXAMPLE:

ECONOMIC ANALYSIS OF THE REPLACEMENT OF ADPE

I. INTRODUCTION

A. Background. The computer at a certain Navy activity is completely saturated. In order to accomplish the current workload, the activity is operating the computer around the clock at full capacity. In addition, the activity is performing the workload using commercial timesharing services. The overall workload at the activity is expected to continue to grow each year. Since the in-house computer is completely saturated all new workload must be handled through timesharing. Due to the high timesharing costs, the Commander of the activity directed that a study be made to investigate the feasibility of replacing the current hardware with a larger, more efficient machine. Replacement of the current equipment would allow the activity to bring all timesharing workload in house. In addition it would allow the activity to accomplish its workload by operating two shifts per day instead of three, thus reducing personnel costs by 1/3.

B. Scope. In keeping with GSA policy, the analysis examined the replacement of current equipment under a competitive procurement. Thus, the alternative to augment current equipment with compatible equipment via a sole source procurement was not considered.

C. Methodology. The basic approach of this analysis was to compare the costs and benefits of the proposed ADPE procurement with the current system. This was done by first examining the current and projected ADP workload at the activity. Once the workload was established ADPE requirements for a new Brand Z computer were determined as well as future timesharing requirements under the current system. Costs and benefits for both alternatives were identified. The alternatives were compared in terms of their present value costs over a nine year period. A sensitivity analysis was performed to determine to what degree changes in certain cost factors would affect the overall results of the analysis.

II. OBJECTIVE

The objective of this analysis is to examine the economic feasibility of replacing the existng ADP system with new equipment.

III. ASSUMPTIONS

A. The size of the new system must be large enough to support the current in-house and timesharing workload as well as all projected workload growth throughout the life-cycle.

B. The economic life of the system is seven years from the point of full implementation.

C. Only major vendors can absorb the cost of running the benchmark, therefore, only major vendors will bid.

D. The two compatible major vendors will continue their practice of non-competitive bidding, thus the procurement will result in non-comaptible equipment.

E. Six months are required to transfer the in-house workload to the Brand Z computer and three months are required to transfer the timesharing workload.

G. All new applications developed after the installation of new equipment will use the new equipment without conversion.

H. ADPE will be leased.

I. All costs and salaries reflect those in effect during FY79. No provision is made for inflation.

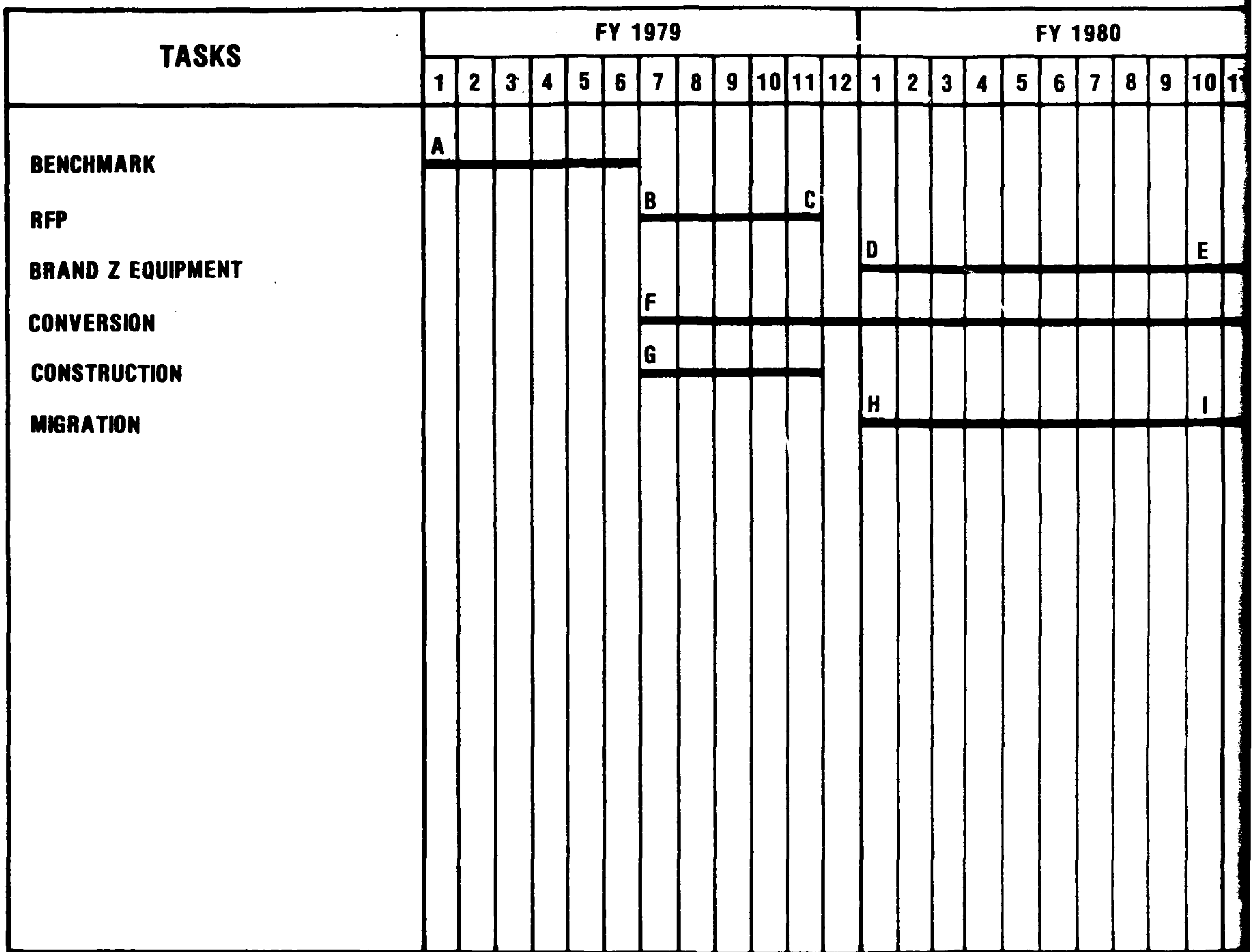
J. MILCON funding will be available for construction of additional space.

K. Major milestones for the proposed alternative are identified in Figure F-1.

IV. ALTERNATIVES

A. Current System. The activity will continue to operate the computer center as it does today. Because the computer center is already operating three shifts per day at full capacity no additional staffing or in-house operating costs will be required in the out years. All new workload will be supported through commercial timesharing.

B. Brand Z System. The existing ADP equipment will be replaced through a traditional competitive procurement. A benchmark package will be constructed by contractors, assisted by in-house personnel. Vendors bidding on the contract will be required to perform the benchmark at their own expense. The Brand Z contract will be awarded to the best vendor. A massive conversion effort will be undertaken to make all existing programs compatible with the new equipment. The migration of



A BEGIN BENCHMARK CONSTRUCTION

B ISSUE RFP

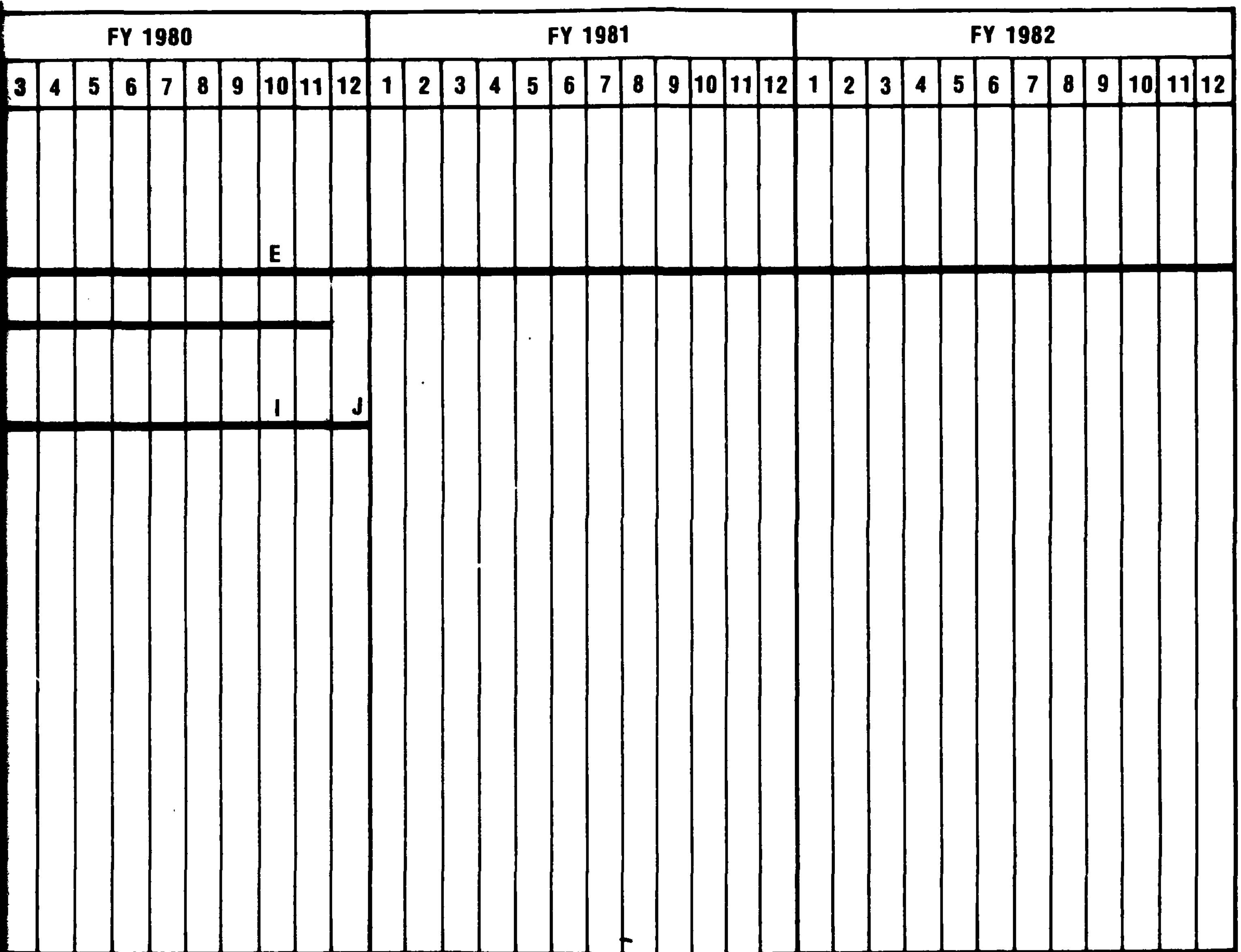
C AWARD BRAND Z CONTRACT

D INSTALL BRAND Z EQUIPMENT

E RELEASE CURRENT EQUIPMENT

Figure F-1

MAJOR MILESTONES



F BEGIN CONVERSION

G BEGIN CONSTRUCTION

H BEGIN MIGRATION OF INHOUSE WORKLOAD

I BEGIN MIGRATION OF TIMESHARING WORKLOAD

J SYSTEM IS FULLY OPERATIONAL

.2

in-house workload will occur between October 1979 and June 1980 at which time the current equipment will be released. The timesharing workload will be migrated from July though September 1980. Once the Brand Z system is fully operational the computer center will reduce operations from three to two shifts per day. At this time approximately 1/3 of the personnel will be released.

V. COST ANALYSIS

Nonrecurring and recurring costs were computed for each alternative. Nonrecurring costs are those costs made on a one-time basis. Recurring costs are those costs incurred on a periodic basis throughout the project life. Nonrecurring and recurring costs are identified in Tables F-1 through F-3. Cost elements are described below.

A. Nonrecurring Costs

1. Benchmark Construction. The benchmark package will be contracted out for an estimated cost of $335,000. A six person benchmark team will be established at the activity to assist the contractors in preparing the benchmark package. The cost for the benchmark team includes salaries, travel, per diem and miscellaneous expenses for a six-week period. Based on a GS-13, step 5 the salary and fringe benefits will cost $4523 per person. Travel costs are estimated for three trips at a transportation cost of $1000 per person and per diem for 42 days at $50 per day. Miscellaneous expenses include rental of two cars for six weeks at $100 per car per week. The total cost for the benchmark team is $46,900.

2. Conversion. Conversion costs are based on manpower estimates provided by NAVDAC's Project Management Control System (PMCS). The conversion will be contracted out at a cost of $45,000 per manyear. The conversion effort will require 125 manyears and will take place over a 17 month timeframe. The total conversion cost is $5,625,000.

3. Construction. Alternative B will require construction of additional floor space to support the Brand Z equipment. The total construction cost is $1,263,200 and consists of construction of 8,000 square feet at $129 per square foot to house the computers and support equipment and construction of 3400 square feet at $68 per squre foot to house the Uninterruptable Power Supply (UPS) upgrade.

4. Initial Computer Room Equipment. Miscellaneous computer room support equipment (tape storage racks, tape cleaners, tables, console operator chairs, etc.) will be installed to support the initial Brand Z equipment. This equipment will cost $30,000.

TABLE F-1
NONRECURRING COSTS ($000)
ALTERNATIVE: B

COST CATEGORY	FY79	FY80	FY81	FY82	TOTAL
Benchmark Construction					
a. Benchmark Package	$335.0				$335.0
b. In-house Benchmark Team	46.9				46.9
Conversion	1985.3	$3639.7			5625.0
Construction	1263.2				1263.2
Computer Room Equipment		30.0			30.0
UPS Upgrade	610.1			$723.5	1333.6
Migration of Workload					
a. In-house Workload		707.2			707.2
b. Timesharing Workload		283.2			283.2
Supplies		174.2			174.2
Utilities					
a. Computer power		110.6			110.6
b. General Utilities		47.4			47.4
[illegible]onnel Separation		105.2			105.2
[illegible] Value of [illegible] Equipment		(1650.0)			(1650.0)
TOTALS	$4240.5	$3447.5		$723.5	$8411.5

COST CATEGORY	FY79	FY80	FY81	FY82	FY83
ADP Timesharing	$ 420.9	$ 704.9	$1387.6	$1804.5	$2344.3
ADPE Rental/ Maintenance	4248.0	4248.0	4248.0	4248.0	4248.0
Utilities					
Computer Power	248.8	248.8	248.8	248.8	248.8
General Utilities	106.6	106.6	106.6	106.6	106.6
Personnel	3616.8	3616.8	3616.8	3616.8	3616.8
Supplies	550.0	550.0	550.0	550.0	550.0
TOTAL	$9191.1	$9475.1	$10,157.8	$10,574.7	$11,114.[illegible]

TABLE F-2

RECURRING COSTS ($000)

ALTERNATIVE A

0	FY81	FY82	FY83	FY84	FY85	FY86	FY87	TOTAL
4.9	$1387.6	$1804.5	$2344.3	$3049.2	$3963.6	$5151.8	$ 6696.6	$25,523.4
8.0	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	4248.0	38,232.0
8.8	248.8	248.8	248.8	248.8	248.8	248.8	248.8	2232.0
6.6	106.6	106.6	106.6	106.6	106.6	106.6	106.6	959.4
6.8	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	3616.8	32,551.2
0.0	550.0	550.0	550.0	550.0	550.0	550.0	550.0	4950.0
5.1	$10,157.8	$10,574.7	$11,114.5	$11,819.4	$12,733.8	$13,922.0	$15,466.8	$104,455.2

N

COST CATEGORY	FY79	FY80	FY81	FY82	FY83	
ADP Timesharing	$ 420.9	$ 420.9				
ADPE Rental/Maintenance						
Current Equipment	4,248.0	3,186.0				
Brand Z Equipment		4,825.0	$4,825.0	$4,825.0	$4,825.0	$4
Utilities						
Computer Power	248.8	235.0	276.5	290.3	304.8	
General Utilities	106.6	100.7	118.5	124.4	130.6	
Personnel	3,616.8	3,315.4	2,411.2	2,531.8	2,658.3	2
Supplies	550.0	550.0	577.5	606.4	636.7	
TOTAL	$9,191.1	$12,633.0	$8,208.7	$8,377.9	$8,555.4	$

TABLE F-3
RECURRING COSTS ($000)
ALTERNATIVE B

0	FY81	FY82	FY83	FY84	FY85	FY86	FY87	TOTAL
20.9								$ 841.8
86.0								7,434.0
25.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	$4,825.0	38,600.0
35.0	276.5	290.3	304.8	320.1	336.1	352.9	370.5	2,735.0
00.7	118.5	124.4	130.6	137.2	144.0	151.2	158.8	1,172.0
15.4	2,411.2	2,531.8	2,658.3	2,791.3	2,930.8	3077.4	3,231.2	26,564.2
50.0	577.5	606.4	636.7	668.5	702.0	737.1	773.9	5,802.1
33.0	$8,208.7	$8,377.9	$8,555.4	$8,742.1	$8,937.9	$9,143.6	$9359.4	$83,149.1

5. Upgrade of UPS System. The ADP power requirement will increase for the Brand Z equipment. An initial UPS upgrade of 550 KVA will be required to support the Brand Z configuration. In year 4 an additional upgrade of 650 KVA will be required. The costs of the upgrades in years 1 and 4 are $610,100 and $725,500 respectively.

6. Migration of Workload. Migration is the transfer of the in-house and timesharing workload to the Brand Z equipment. The effort will be performed by in-house overtime personnel. Based on the MPCS the total effort will require 69,600 hours of overtime (49,700 hours for the in-house workload and 19,900 hours for the timesharing workload). The migration effort was costed using the overtime rate for a GS-6 step 5. The hourly overtime cost including fringe benefits and leave is $14.23. Thus, the migration costs for the in-house and timesharing workloads are $707,200 and $283,200 respectively.

7. Supplies. The estimated cost of supplies needed for the migration effort is $174,200.

8. Utilities. Approximately 400 KVAs needed for the migration effort. Based on a NAVFAC estimating formula the computer power cost is $110,600 (400 KVA x .8 usage factor x $.04 cost factor x 720 hours per month x 12 months). Past experience has shown that the computer power requirement represents 70% of the total utilities cost, while general utilities including air conditioning, lighting, etc., comprise the other 30%. Based on this information the general utilities cost is $47,400.

9. Personnel Separation Costs. Personnel requirements will be reduced by 1/3 (i.e., eight military, 64 civilians) when one shift is eliminated. The military billets will be reduced through normal attrition. Since the military are routinely transferred to new duty stations at the end of their tours, there are no separation costs incurrred.

Civilian employees whose jobs are eliminated will be given priority rights to other vacant positions in DOD and in other Federal agencies. Civilian employees who do not get other jobs or who do not retire will be separated. Based on past DOD experience approximately 75% of those whose jobs are eliminated will find other jobs or retire. The other 25% will be separated. The estimated cost to separate an employee is $6575. Thus, the estimated separation cost for 16 civilians is $105,200.

10. Terminal Values of Owned Equipment. Part of the current equipment is government owned. When Brand Z is fully operational this equipment can be released for sale or for re-utilization by other government activities. The projected market value for the equipment at the time of its release is $1,650,000.

B. Recurring Costs

1. ADP Timesharing. Because current ADP capacity has become saturated, workload is being performed using commercial timesharing. The costs for the timesharing services is $2014 per CPU hour. Unless new equipment is acquired, timesharing is expected to increase each year to accommodate the ADP workload growth. Projected timesharing workload and its costs are shown in Table F-4.

TABLE F-4

PROJECTED TIMESHARING WORKLOAD

Year	CPU Hours	Costs
1	209	$ 420,900
2	350	704,900
3	689	1,387,600
4	896	1,804,500
5	1164	2,344,300
6	1514	3,049,200
7	1968	3,963,600
8	2558	5,151,800
9	3325	6,696,600
		$25,523,400

2. ADPE Rental/Maintenance

a. Current Equipment. Annual rental/maintenance for the present ADPE is $4,248,000. Under Alternative A this cost will be incurred throughout the project life. Under Alternative B this cost will be incurred until the equipment is released.

b. Brand Z Equipment. The annual rental/maintenance for Brand Z equipment is $4,825,000.

3. Utilities

a. Current Equipment. The current equipment requires 900 KVA to accomplish the in-house workload. Based on

the NAVFAC formula the computer power cost is $248,800 (900 KVA x .8 usage factor x .04 cost factor x 720 hours per month x 12 months per year). The cost for general utlities is $106,600. Since the current equipment is already saturated no provisions are made for workload growth.

b. Brand Z Equipment. The Brand Z equipment requires 700 KVA to handle the current in-house workload and 300 KVA to handle the initial timesharing workload. Based on the NAVFAC formula the utilities cost for FY81 (the first year of full implementation) is $276,500 for computer power and $118,500 for general utilities. Utilities costs will increase 5% each year thereafter due to workload growth.

4. Personnel. Civilian personnel costs were based on current annual salaries defined by the General Schedule pay rates. Salaries were adjusted in accordance with Office of Management and Budget guidance to include a 26% fringe benefit factor. Military personnel costs are based on the composite military pay rates identified in the NAVCOMPT manual and are adjusted to include a 25% fringe benefit factor for officers and a 40% factor for enlisted personnel.

a. Alternative A. The computer activity currently runs three shifts per day, requring 216 people. Personnel costs are identified in Table F-5. The annual personnel costs are approximately $3,616,800 and will remain constant throughout the entire life-cycle.

TABLE F-5

CURRENT PERSONNEL REQUIREMENTS

Grade	Number of People	Annual Salary	Salary + Fringe Benefits	Personnel Costs
E-5	12	$11,507	$16,110	$ 193,320
E-4	9	9,747	13,646	122,814
O-5	3	34,047	42,559	127,677
GS-7	24	14,750	18,585	446,040
GS-6	120	13,272	16,723	2,006,760
GS-5	48	11,907	15,003	720,144
TOTALS	216			$3,616,755

b. Alternative B. Alternative B will operate with current personnel until 1 July 1980 when the Brand Z equipment becomes fully operational for in-house workload. At that time, the current equipment will be released and the activity will run two shifts per day, reducing initial personnel requirements by 1/3. Personnel costs to support initial requirements are

$2,411,200 and are identified in Table F-6. Beginning in FY82 and each year thereafter personnel costs are expected to increase by 5% to handle the growth in workload.

TABLE F-6

INITIAL PERSONNEL REQUIREMENTS FOR BRAND Z

Grade	Number of People	Annual Salary	Salary + Fringe Benefits	Personnel Costs
E-5	8	$11,507	$16,110	$ 128,880
E-4	6	9,747	13,646	81,876
O-5	2	34,047	42,559	85,118
GS-7	16	14,750	18,585	297,360
GS-6	80	13,272	16,723	1,337,840
GS-5	32	11,907	15,003	480,096
TOTALS	144			$2,411,170

5. Supplies

a. Alternative A. The current cost for forms, cards, ribbons and other ADP related supply items is $550,000 per year. For alternative A this value will remain constant throughout the life-cycle.

b. Alternative B. During years 1 and 2 supplies will be the same as Alternative A. Beginning in year 3, supply costs will increase by 5% per year to handle the increased workload.

VI. BENEFIT ANALYSIS

A number of benefits and disadvantages were identified with the proposed alternative.

A. Benefits

1. Workload can be processed at a more rapid speed, resulting in faster turnaround time for the users.

2. The new equipment provides better reliability. There is less chance that the system will go down. If the system does go down it will be easier to repair. Thus, overall downtime of the system will be significantly reduced.

3. The new equipment will provide greater accuracy. All batch processing will be eliminated. Data entry will be key to disk, thus eliminating keypunch errors. Reduction of input errors will result in fewer corrections and fewer reruns.

4. The new equipment will retain a 33% surge capacity (3rd shift) to support crisis and exercise operation.

5. The current system does not meet minimum security requirements. The proposed alternative is designed to provide a high security environment.

B. Disadvantages

1. The continuity of operations will be interrupted during the migration period. The current staff is proficient in running the existing equipment. However, they will require special training and on the job experience to become equally proficient in operating the new equipment.

2. The proposed alternative requires MILCON funding. If MILCON funding is not obtained implementation would be delayed.

3. A number of jobs will be eliminated in a geographic area where the employment rate is already depressed.

VII. COMPARISON OF ALTERNATIVES

A. Present Value Analysis. Present value analyses were performed on Alternatives A and B and are presented in Tables F-7 and F-8. The results show that the discounted life-cycle cost for the current system is $67,331,200 and the discounted life-cycle cost of the proposed system is $63,947,900. Thus, the proposed system is economically feasible, yielding net discounted savings of $3,383,300.

B. Break-Even Analysis. Figure F-2 graphically displays the commulative discounted costs for each alternatve. The break-even point (i.e., the point in time at which the cumulative costs for both alternatives are equal) occurs during FY86. Before that time Alternative A is less costly. After that time Alternative B becomes cost advantageous.

VIII. SENSITIVITY ANALYSIS

A sensitivity analysis was conducted to determine whether or not changes in certain input values would effect the outcome of the analysis. Three variables were tested: conversion costs; Brand Z ADPE rental/maintenance and; timesharing workloads. Each factor was tested independently by changing the original estimate by 10%, 25% and 50% while holding all other parameters constant. Discounted life-cycle costs were then computed for each alternative based on the new estimates. Results of the three tests are described below.

TABLE F-7
PRESENT VALUE ANALYSIS
ALTERNATIVE: A
($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY79		9,191.1	9,191.1	.954	8,768.3	8,768.3
FY80		9,475.1	9,475.1	.867	8,214.9	16,983.2
FY81		10,157.8	10,157.8	.788	7,980.7	24,963.9
FY82		10,574.7	10,574.7	.717	7,582.1	32,546.0
FY83		11,114.5	11,114.5	.652	7,246.7	39,792.7
FY84		11,819.4	11,819.4	.592	6,997.1	46,789.8
FY85		12,733.8	12,733.8	.538	6,850.8	53,640.6
FY86		13,922.0	13,922.0	.489	6,807.9	60,448.5
FY87		15,466.8	15,466.8	.445	6,882.7	67,331.2

TABLE F-8
PRESENT VALUE ANALYSIS

ALTERNATIVE: B

($000)

PROJECT YEAR	NONRECURRING COSTS	RECURRING COSTS	TOTAL COST	DISCOUNT FACTOR	DISCOUNTED COSTS	CUMULATIVE DISCOUNTED COSTS
FY79	$4,240.5	$ 9 191.1	$13,431.6	.954	$12,813.7	$12,813.7
FY80	3,447.5	12,633.0	16,080.5	.867	13,941.8	26,755.5
FY81		8,208.7	8,208.7	.788	6,468.5	33,224.0
FY82	723.5	8,377.9	9,101.4	.717	6,525.7	39,749.7
FY83		8,555.4	8,555.4	.652	5,578.1	45,327.8
FY84		8,742.1	8,742.1	.592	5,175.3	50,503.1
FY85		8,937.9	8,937.9	.538	4,808.6	55,311.7
FY86		9,143.6	9,143.6	.489	4,471.2	59,782.9
FY87		9,359.4	9,359.4	.445	4,164.9	63,947.9

BREAK-EVEN ANALYSIS

DISCOUNTED LIFE-CYCLE COSTS

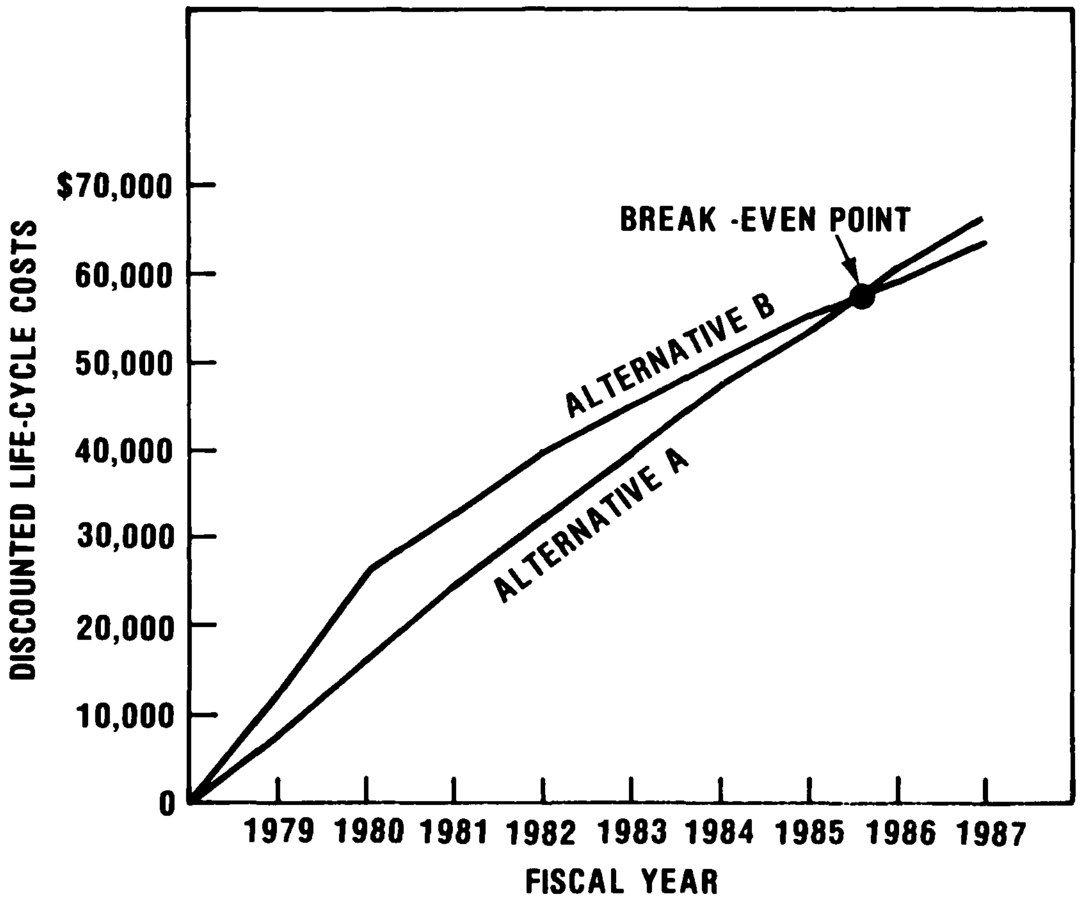


Figure F-2

A. Conversion Costs. Table F-9 shows what would happen if conversion costs were 10%, 25%, and 50% higher than the original estimate. Since conversion costs would be incurred only under the proposed alternative, the discounted life-cycle cost of $67,331,200 for Alternative A will remain unchanged. Discounted life-cycle costs for Alternative B would be:

	Undiscounted Conversion Costs 1979	Undiscounted Conversion Costs 1980	Discounted Life-Cycle Costs
Original estimate	$1,985,300	$3,639,700	$63,947,900
+10%	2,183,800	4,003,700	64,452,800
+25%	2,481,600	4,549,600	65,210,200
+50%	2,978,000	5,459,600	66,472,700

In all three cases life cycle costs for Alternative B are less than Alternative A. Therefore, the analysis is not sensitive to changes in conversion costs at any of these levels. The actual point of sensitivity occurs when conversion costs are increased by 67%. This value was computed by performing the following algebraic break-even analysis.

$$
\begin{aligned}
\text{Alternative A} &= \text{Alternative B} \\
\$67{,}331.2 &= \$63{,}947.9 + \$1985.3x\ (.954) + \$3939.7x\ (.867) \\
\$3{,}383.3 &= \$1894.0x + \$3{,}155.6x \\
\$3{,}383.3 &= \$5049.6x \\
x &= .67
\end{aligned}
$$

B. Brand Z ADPE Rental/Maintenance. Table F-10 shows what would happen if Brand Z ADPE costs were increased by 10%, 25% and 50%. Alternative A would not be affected by the increase. Costs for Alternative B would be:

	Annual Brand Z ADPE	Discounted Life-Cycle Costs
Original Estimate	$4,825,000	$63,947,900
+10%	5,307,500	66,402,900
+25%	6,031,300	70,085,300
+50%	7,237,500	76,222,700

The economic analysis is not sensitive to a 10% change; however, it is sensitive to changes of 25% and 50%. The actual point of sensitivity occurs when Brand Z ADPE costs are increased by 13.8%, as computed:

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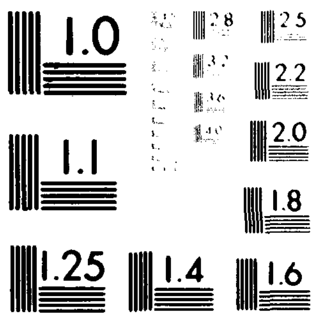

MICROCOPY RESOLUTION TEST CHART

TABLE F-9

SENSITIVITY ANALYSIS

CONVERSION COSTS

($000)

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A		ALTERNATIVE B					
		NO CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	$ 9,191.1	$ 8,768.3	$13,630.1	$13,003.1	$13,927.9	$13,287.2	$14,424.3	$13,760.8
FY80	.867	9,475.1	16,983.2	16,444.5	27,260.5	16,990.4	28,017.9	17,900.4	29,280.4
FY81	.788	10,157.8	24,963.9	8,208.7	33,729.0	8,208.7	34,486.4	8,208.7	35,748.9
FY82	.717	10,574.7	32,546.0	9,101.4	40,254.7	9,101.4	41,012.1	9,101.4	42,274.6
FY83	.652	11,114.5	39,792.7	8,555.4	45,832.8	8,555.4	46,590.2	8,555.4	47,852.7
FY84	.592	11,819.4	46,789.8	8,742.1	51,008.1	8,742.1	51,765.5	8,742.1	53,028.0
FY85	.538	12,733.8	53,640.6	8,937.9	55,816.7	8,937.9	56,574.1	8,937.9	57,836.6
FY86	.489	13,922.0	60,448.5	9,143.5	60,287.9	9,143.6	61,045.3	9,143.6	62,307.8
FY87	.445	15,466.8	67,331.2	9,359.4	64,452.8	9,359.4	65,210.2	9,359.4	66,472.7

TABLE F-10
SENSITIVITY ANALYSIS
BRAND Z ADPE COSTS
($000)

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A		ALTERNATIVE B					
		NO CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	$ 9,191.1	$ 8,768.3	$13,431.6	$12,813.7	$13,431.6	$12,813.7	$13,431.6	$12,813.7
FY80	.867	9,475.1	16,983.2	16,563.0	27,173.8	17,286.8	27,801.4	18,493.0	28,847.1
FY81	.788	10,157.8	24,963.9	8,691.2	34,022.5	9,415.0	35,220.4	10,621.2	37,216.6
FY82	.717	10,574.7	32,546.0	9,583.9	40,894.2	10,307.7	42,611.0	11,513.9	45,472.1
FY83	.652	11,114.5	39,792.7	9,037.9	46,786.9	9,761.7	48,975.6	10,967.9	52,623.2
FY84	.592	11,819.4	46,789.8	9,224.6	52,247.9	9,948.4	54,865.1	11,154.6	59,226.7
FY85	.538	12,733.8	53,640.6	9,420.4	57,316.1	10,144.2	60,322.7	11,350.4	65,332.2
FY86	.489	13,922.0	60,448.6	9,626.1	62,023.3	10,349.9	65,383.8	11,556.1	70,984.1
FY87	.445	15,466.6	67,331.2	9,841.9	66,402.9	10,565.7	70,085.5	11,771.9	76,222.6

$$\begin{aligned} \text{Alternative A} &= \text{Alternative B} \\ \$67{,}331.2 &= \$63{,}947.9 + \$4{,}825x\ (5.088) \\ \$3{,}383.3 &= \$24{,}549.6x \\ x &= .138 \end{aligned}$$

C. Timesharing Workload. Projected growth in timesharing workload was a major factor which led to the proposal to replace existing equipment. Because of the uncertainties associated with projecting future workload, a contingency analysis was performed to determine what happens if future workload is actually less than what was projected. The results of the analysis are shown in Table F-11. Life-cycle costs for both alternatives would be affected since timesharing costs would be incurred in either case. Timesharing workloads identified in Table F-4 were decreased by 10%, 25% and 50%. The discounted life-cycle costs brought about by these changes are:

	Alternative A	Alternative B
-10%	$65,918,100	$63,871,200
-25%	63,763,300	63,756,300
-50%	60,171,900	63,564,500

The results show that the analysis is not sensitive at the 10% level. At the 25% level life-cycle costs are approximately the same for both alternatives. Thus, this is the break-even point. If timesharing workload is decreased by more than 25%, Alternative B would no longer be the least costly alternative.

IX CONCLUSIONS

The results of the economic analysis showed that the proposed alternative is economically feasible. The alternative becomes cost effective in FY86 and yields discounted life-cycle savings of $3,383,300. The major savings can be attributed to the elimination of the timesharing workload. In addition to being the less costly alternative, Alternative B can process the workload with greater speed, accuracy and reliability.

X. RECOMMENDATIONS

Based on the results of the economic analysis, Alternative B is recommended for implementation.

FISCAL YEAR	DISCOUNT FACTOR	ALTERNATIVE A					
		10% CHANGE		25% CHANGE		50% CHANGE	
		UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
FY79	.954	8,728.1	8,728.1	9,085.9	8,667.9	8,980.6	8,567.5
FY80	.867	8,153.8	16,881.9	9,298.9	16,730.0	9,122.6	16,476.8
FY81	.788	7,895.0	24,881.9	9,810.9	24,461.0	9,464.0	23,934.4
FY82	.717	7,452.6	32,229.5	10,123.6	31,719.6	9,672.4	30,869.5
FY83	.652	7,093.8	39,323.3	10,528.4	38,584.1	9,942.3	37,351.9
FY84	.592	6,816.9	46,140.2	11,057.1	45,129.9	10,294.8	43,446.4
FY85	.538	6,637.5	52,777.7	11,742.9	51,447.6	10,752.0	49,231.0
FY86	.489	6,555.9	59,333.6	12,634.0	57,625.6	11,346.1	54,779.2
FY87	.445	6,584.7	65,918.1	13,792.6	63,763.3	12,118.5	60,171.9

TABLE F-11
SENSITIVITY ANALYSIS
TIMESHARING WORKLOAD
($000)

		ALTERNATIVE B					
50% CHANGE		10% CHANGE		25% CHANGE		50% CHANGE	
UNTED T	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST	UNDISCOUNTED COST	CUMULATIVE DISCOUNTED COST
80.6	8,567.5	13,389.5	12,773.6	13,326.4	12,713.4	13,221.1	12,612.9
22.6	16,476.8	16,038.4	26,678.9	15,975.3	26,564.0	15,870.0	26,372.2
64.0	23,934.4	8,208.7	33,147.4	8,208.7	33,032.5	8,208.7	32,840.7
72.4	30,869.5	9,101.4	39,673.1	9,101.4	39,558.2	9,101.4	39,366.4
42.3	37,351.9	8,555.4	45,251.2	8,555.4	45,136.3	8,555.4	44,944.5
94.8	43,446.4	8,742.1	50,426.5	8,742.1	50,311.6	8,742.1	50,119.8
52.0	49,231.0	8,937.9	55,235.1	8,937.9	55,120.2	8,937.9	54,928.4
46.1	54,779.2	9,143.6	59,706.3	9,143.6	59,591.4	9,143.6	59,399.6
18.5	60,171.9	9,359.4	63,871.2	9,359.4	63,756.3	9,359.4	63,564.5

2

APPENDIX G

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